

#### SPACE TUG SYSTEMS STUDY (CRYOGENIC) SEPTEMBER DATA DUMP

VOLUME 6 Operations Book 3 Option 3

SEPTEMBER 1973

PREPARED BY: SPACE TUG STUDY TEAM

APPROVED BY

L. Q. WESTMORELAND STUDY MANAGER

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PREPARED FOR NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
UNDER CONTRACT NO. NASS-29677



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#### PREFACE

This study report for the Tug Program is submitted by the McDonnell Douglas Astronautics Company (MDAC) to the Government in partial response to Contract Number HAS8-29677.

The current results of this study contract are reported in eight volumes:

Volume 1 - Summary, Program Option 1

Volume 2 - Summary, Program Option 2

Volume 3 - Summary, Program Option 3

These three summary volumes present the highlights of the comprehensive data base generated by MDAC for evaluating each of the three program options. Each volume summarizes the applicable option configuration definition, Tug performance and capabilities, orbital and ground operations, programmatic and cost considerations, and sensitivity studies. The material contained in these three volumes is further summarized in the Data Dump Overview Briefing Manual.

Volume 4 — Mission Accomplishment. (3 Books and 1 Supplement Bound Together)

This volume contains mission accomplishment analysis for each of the three program options and includes the tug system performance, mission capture, and fleet size analysis.

Volume 5 - Systems (3 Books)

This volume presents the indepth design, analysis, trade study, and sensitivity technical data for each of the configuration options and each of the Tug systems i.e., structures, thermal, avionics, and propulsion. Interface with the Shuttle and Tug payloads for each of the three options is defined.

Volume ( - Operations (3 Books)

This volume presents the results of orbital and ground operations trades and optimization studies for each option in the form of operations descriptions, time lines, support requirements (GSE, manpower, networks, etc.), and resultant costs.

Volume 7 — Safety (3 Books)

This volume contains safety information and data for the Tug Program. Specific safety design criteria applicable to each option are determined and potential safety hazards common to all options are identified.

Volume 8 - Programmatics and Cost (3 Books)
This volume contains summary material on Tug Program manufacture, facilities,
vehicle test, schedules, cost, project management SR&T, and risk assessment for
each option studied.

These volumes contain the data required for the three options which were selected by the Government for this part of the study and are defined as:

- A. Option 1 is a direct development program (I.O.C.: Dec 1979). It is a direct development program (I.O.C.: Dec 1979). It is designed for a 36-hour mission. MDAC has also prepared data for an alternative to Option 1 which deviates from certain requirements to achieve the lowest practicable DDT&E cost.
- B. Option 2 is also a direct development program (I.O.C.: 1983). It emphasizes total program cost effectiveness in addition to low DDT&E cost. The deployment requirement is 3500 pounds minimum into geosynchronous orbit and 3500 pounds minimum retrieval from geosynchronous orbit.
- Option 3 is a phased development program (I.O.C.: 1979 phased to I.O.C. 1983). It emphasizes minimum initial DDT&E cost and low total program cost. The initial Tug capability will deploy a minimum of

3500 pounds into geosynchronous orbit without retrieval capability, however, through phased development, it will acquire the added capability to retrieve 2200 pounds from geosynchronous orbit. The impact of increasing the retrieval capability to 3500 pounds is also provided.

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#### VOLUME 6 OPERATIONS OPTION 3

1.0 CONFIGURATION SUMMARY

#### . DESIGN

#### STRUCTURE

• LO2 / LH2 TANK: 2219 TAPER

OUTER SHELL: AL-ISOGRID

• THRUST STRUCT: FG ISOGRID

• TANK SUPPORTS: FG TUBE

#### AVIONICS

• COMPUTER: REDUNDANT 16 BIT, 16 K WD8

• GUID / NAV: .0 30 STAR TRACKER

. POWER: BATTERIES 646 WATTS (TUG)

0 (TO P/L)

#### PROPULSION

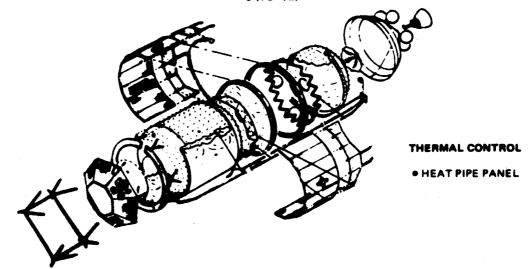
• CATEGORY I RL-10

5.5: 1 EMR

441.8 18P

● PRESS: AMB. HE

• APS: MONO-PROP



#### SIZE

• DRY WEIGHT: 6309 LB

● LENGTH 392 3 IN.

● DIA 17€ II...

• LO<sub>2</sub> 42,855 LB

• LH., 7,894 LB

#### PERFORMANCE

• MISSION DURATION: 1.5 DAYS

• P / L DEPLOY: 4360 LB

• ROUNDTRIP: 1630 LB

· AUTONOMY LEVEL: IV

• PLACEMENT ACCURACY: 34.9 N. MI.

#### PROGRAM DESCRIPTION

• IOC DEC 31 1979

• DEVELOPMENT TIME TO IOC: 51 MO

• FLEET SIZE: 4

● NO. OF FLTS: ETR / WTR: 74 / 8

• PROG. COST:

DOT & E: TBD INVEST.: TBD TBD

Figure (. Configuration Summary Option 31

#### • DESIGN

#### STRUCTURE

• LO2 / LH2 TANK: 2219 TAPER

OUTER SHELL: AL - ISOGRID

• THRUST STRUCT: FG ISOGRID

• TANK SUPPORTS: FG TUBE

#### **AVIONICS**

• COMPUTER: REDUNDANT 16 BIT, 16 K WDS

• GUID / NAV: •0 30 STAR TRACKER

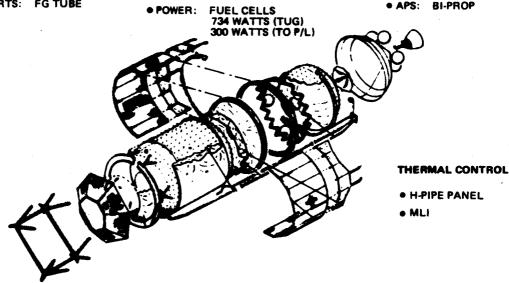
• RENDZ. & DOCK: LASER RADAR

#### PROPULSION

• CATEGORY | RL-10 5.5: 1 EMR 441.8 ISP

• PRESS: COLD HE

APS: BI-PROP



#### SIZE

• DRY WEIGHT: 6096 LB

• LENGTH: 407.3 IN.

• DIA: 176 IN.

● LO<sub>2</sub>: 47,363 LB

● LH<sub>2</sub>: 7,894 LB

#### PERFORMANCE

• MISSION DURATION: 6 DAYS

• P/L DEPLOY: 6890 LB • ROUNDTRIP: 4140 LB • AUTONOMY LEVEL: III

• PLACEMENT ACCURACY: 69.7 N. MI.

#### PROGRAM DESCRIPTION

• IOC: DEC 31 1983

• DEVELOPMENT TIME TO IOC: 51 MO.

• FLEET SIZE: 8

• NO. OF FLTS: ETR / WTR: 234 / 50

• PROG. COST:

DOT & E: TBD INVEST .: TBD OPS.: TBD

Figure 2. Configureation Summary Option 3F

#### 2.0 Orbital Operations Summary

The following paragraphs summarize the orbital operations of the tug and associated ground support of orbital ops.

#### 2.1 Mission Performance

The performance capability was computed for each mission in the mission model and for each mission mode - deploy, retrieve, round trip and expendable. Table 2.1-1 summarizes the general mission descriptions. The performance results are given in Tables 2.1-2 through -4 for options 3I, 3F and 3S. A discussion of the derivation and applications of these data is presented in Volume IV, Sections 1.1, 1.4, and 1.5.

#### MISSION DESCRIPTIONS

Mission No.	Hax Hp (nmi)	Incl.	Remarks
1-8	19323	0	Synchronous orbit - single burn transfer orbit injection
A5-1	19323	0	Synchronous orbit - two burn transfer injection
1-8B	19323	0	Synchronous orbit - two burn transfer injection with 600 fps for multiple payload deployments
9	lau	Eclip.	
10	6900	55°	
10A	6900	55°	Alternate - Shuttle launched into 28.5°
11	16Kx30K	20°	
12	180x1800	90°	
13	1Kx20K	90°	
13A	1Kx20K	90°	ETR Alternate - Shuttle launched into 28.5°
13B	1Kx20K	90°	ETR Alternate - Shuttle launched into 55°
14	300x3000	90°	
15	700	100°	
16	500	99.20	
17-8	Interplan	etary	ΔV - 13000
19			16500
20			23000
21-2			24000
23			18400
24			22000
D11	58 <b>K</b>	0,30,60	
D10	860x21K	63.4	Shuttle launch into 63.4° WTR
D10A	860x21K	63.4	ETR Alternate - Shuttle launched into 55°
<b>D</b> 5	750	99°	
D3	13.6Kx25K	60°	Shuttle launched into 60° WTR
D3A	13.6x25K	60°	ETR Alternate - Shuttle launched into 55°
D12	300	1040	
D16	400	98.3°	

TADTE 5.1-5

CONFIGURA	TIØN ØPT 3I	STAGE WT=	=7315.00 IS	P=441.80 DEL	ISP=4.00
MISSIØN	GRØSS-WT V-ØUT	PL-ROUND V-BACK	PL-DEPLØY	PL-RETRI EVE	PL-EXPEND
1-8	62665.00 13972.00	1335.76 13920.00	3588 • 51	2127.81	15925-11
1-8A	62665.00 13890.00	1386 <b>•27</b> 13920 <b>•</b> 00	3724•20	2208 • 27	16060.79
1-8B	62665.00 14190.00	1023.42 14220.00	28 <b>08 •</b> 60	1610.15	15568 • 22
9	62665.00 14160.00	9 64 • 44 1 4 3 5 0 • 0 0	2671 • 27	1509 • 40	15617.01
	50665.00 9700.00	5465.99 9700.00	10882.80	10981-61	18131.98
10A	62665.00 12760.00	2922•37 12760•00	7230•27	4904.86	18013.35
1 i	62665.00 12450.00	3383.05 12450.00	8187.84	5765.07	18576.96
12	32665.00 2285.00	16299 • 57 228 5 • 00	19170.24	108848.31	20458 • 55
. 3	8400.00	2595•66 8400•00	4712.36	5778 • 68	10677.55
13A	62665.00 1 <b>346</b> 0.00	1953.80 13460.00	5080.21	3174.80	16785.40
138	50665.00 11200.00	3014.24 11200.00	6675•72	5495.66	15561 • 43
. 14	32665.00 3600.00	12277.56 3600.00	15852•87	54438 • 61	17983.04
15	26665•00 1700•00	13631.58 1700.00	15380 • 14	119901-62	16318•46
16	26665.00 1120.00	15429 • 58 1120 • 00	16706-52	201869.75	17311.90
17-8	62665.00 13140.00	2309 • 20 13250 • 00	5915•44	3787.85	17339 • 18
19	62665.00	•00	•00	•00	11778.93
	16740.00	17210.00			

20	62665•00 23550•00	•00 24500•00	•00	•00	4459 - 11
21-2	62665•00 24600•00	•00 25500•00	•00	•00	3613.35
23	62665.00 18720.00	•00 19550•00	•00	•00	9275.04
24	62665.00 22500.00	•00 23500•00	•00	•00	5370.34
DII	62665.00 13930.00	1355•44 13930•00	3643.95	2158•24	1 599 4 • 50
D10	48665.00 8500.00	7241•95 8500•00	13241.24	15983.95	19301.04
DIOA	50665.00	528 5 • 80	10599.03	10544.33	17951•97
D5	9800.00 26665.00	9800.00	15221.87	113686.00	16201.30
D3	1770.00 48665.00	1770.00	4016.62	3044•46	13667.44
	11850.00	11850.00		2501 20	14401 47
D3A	50665.00 11920.00	2010.46 11920.00	4686.13	3521.09	14421.47
D15	26665.00 500.00	17522.61 500.00	18155.77	502460.00	18420.09
D16	26665.00 850.00	16318.48 850.00	17333.52	278 667 • 12	17788.52

CONFIGURATION OPT 3F STAGE WT=7039.00 ISP=441.80 DELISP=4.00

MISSIØN	GRØSS-VT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI EVE	PL-EXPEND
1-8	62665.00 13972.00	1611.76 13920.00	4329 • 98	2567•46	16201.11
1-80	62665.00 13890.00	1662•27 13920•00	4465.66	2647•92	16336.79
1-8B	62665.00 14190.00	1299 • 42 14220 • 00	3566-03	2044•38	15844•22
9	62665•00 14160•00	1240.44 14350.00	3435.72	1941.36	15893.01
10	50665.00 9700.00	5741•99 9700•00	11432.32	11536-12	18407.98
10A	62665.00 12760.00	3198.37 12760.00	7913.12	5368.09	18289.35
11	62665.00 12450.00	3659 • 05 12450 • 00	8855.83	6235•41	18852.96
12	32665.00 2285.00	16575•57 2285•00	19494.85	110691.44	20734.55
13	33665•30 8400•00	2871•66 8400•00	5213.43	6393.13	10953.55
1 3A	63665•30 13460•30	2229.80 13460.00	5797.86	3623.29	17061-40
13B	50665.00	3290.24 11200.00	7286•98	5998 •87	15837•43
14	32665.00 3600.00	12553.56 3600.00	16209.24	55662•39	18259.04
15	26665.00 1700.00	13907.58 1 <b>70</b> 0.00	15691.55	122329•31	16594.46
16	26665.00 1120.00	15705.58 1120.00	17005.36	205480.75	17587.90
17-8	62665.00 13140.00	258 5 • 20 13250 • 00	6622•46	4240.58	17615-18
; 9	62665.00 16740.00	.00 17210.00	.00 2-6	•00	12054.93

50	62665.00 23 <b>55</b> 0.00	.00 24500.00	•00	•00	4735•11
21-2	62665.00	•00	•00	•00	3889.35
	24600.00	25500.00		1.	
23	62665•00 18720•00	•00 19550•00	•00	•00	9551.04
24	62665•00 22500•00	•00 23500•00	•00	•00	5646.34
DII	62665.00 13930.00	1631 • 44 13930 • 00	4385•95	2597•71	16270.50
D10	48665•00 8500•00	7517•95 8500•00	13745+88	16593•12	19577.04
DIOA	50665•00 9800•00	5561 •80 9800 • 00	11152-46	11094.91	18227.97
D5	26665•00 1770•00	13700 • 42 1770 • 00	15534.83	116023.31	16477•30
D3	48 665 • 00 1 18 50 • 00	2007.80 11850.00	4656•75	3529 • 66	13943-44
D3A	50665•00 11920•00	228 <b>6 •</b> 46 1 1920 • 00	5329 • 45	4004•47	14697•47
D12	26665.00 500.00	17798 • 61 500 • 00	18441.75	510374•31	18696.09
D16	26665•00 850•00	16594•48 850•00	17626.68	283380•31	18064-52

CONFIGURA	TIØN ØPT 35	STAGE WT	6840.00 IS	SP=462.20 DEL	.ISP=4.00
MI SSI ØN	GRØSS-WT V-ØUT	PL-RØUND V-BACK	PL-DEPLØY	PL-RETRI EVE	PL-EXPEND
1-8	62665.00 13972.00	2608 • 05 13920 • 00	6704.89	4268•34	17449.45
1-8A	62665.00 13890.00	2660.75 13920.00	68 40 • 37	4354.59	17584.93
1-8B	62665.00 14190.00	2281 •84 14220 • 00	5986•85	3687.18	17092.91
9	62665.00 14160.00	2220.16	5876 • 64	3568 • 23	17141.66
10	50665.00 9700.00	6749 • 23 9700 • 00	13032.00	13999 • 58	19399•26
10A	62665.00 12760.00	4257•38 12760•00	10116-85	7350.73	19530•77
11	62665.00 12450.00	4734.06 12450.00	11015-48	8301.93	20091.18
12	32665.00 2285.00	17118 • 16 228 5 • 00	19988 • 11	119221-62	21134-87
13	32665.00 8400.00	3611•15 8400•00	6384•18	8313.75	11636-66
13A	62665.00 13460.00	3251.99 13460.00	8103.52	5431.81	18307.86
13B	50665.00 11200.00	4247•07 11200•00	9078.95	7980.14	16860.77
14	32665.00 3600.00	13203.56 3600.00	16855.63	60939.31	18747.55
15	26665.00 1700.00	14332.89 1700.00	16084.77	131597.75	16920.79
16	26665.00 1120.00	16066.18 1120.00	17334.34	219608.87	17874.23
17-8	62665.00 13140.00	3621.42 13250.00	8896•45	6107•61	18859.71
19	62665.00 16740.00	•00 17210•00	•00 2 - 8	• 00	13291.43

2-8

20	62665.00	•00	•00	•00	5843.98 .
	23550.00	24500.00			
21-2	62665.00	•00	•00	•00	4971.98
	24600.00	25500.00			
23	62665.00	•00	•00	•00	10761 - 29
	18720.00	19550.00		•	
24	62665.00	•00	•00	•00	6780-35
	22500.00	23500.00			
Dii	62665.00	2628 • 59	6762.27	4300.09	17518.75
	13930.00	13930.00			
D10	48665.00	8 520 • 52	15166.02	19445.12	20500-81
	8 500 • 00	8500.00	, , ,		
DIOA	50665.00	6566-13	12764.74	13521 • 58	19221.88
	9800.00	9800.00			
<b>D</b> 5	26665.00	14132.77	15935 • 67	124918.75	16808.23
	1770.00	1770-00			
D3	48665.00	2910.54	6502.31	5269.06	14943.25
	11850.00	11850.00			
D3A	50665.00	3215.31	7217.38	5798 • 54	15731.05
	11920.00	11920.00			
D12	26665.00	18076-26	18 699 •8 4	542067.44	18935.80
	500.00	500 • 00			
	300.00	300 •00			
D16	26665•00	16920.80	17925.08	302013.50	18331.05
DIO	850.00	8 50 • 00	. / / 23 + 00	JUDU 1.0 1.0 1	

#### MISSION DURATION

One of the factors affecting flight operations effort (or cost) is mission duration. Since there are many different types of missions which vary in time on orbit and since some of the ground support tasks are proportional to mission duration it was necessary to calculate a time for each mission required by the mission model. This was done by using the timelines for the reference missions. The ground rules for computing these times and a list of missions with the calculated time for each are shown below. In order to simplify the computer programming for the flight operations cost runs the specific mission times for all the missions flown for a given year were averaged to produce a single number for that year which would provide the proper results.

GROUND RULES FOR COMPUTING MISSION TIMES FROM THE REFERENCE MISSION TIMELINES

Mission time is defined as the total elapsed time from Shuttle launch to Orbiter landing.

- 1. For Option 1 and Initial Phase of Option 3:
  - a. For dedicated missions the Tug on orbit time (from Orbiter deployment to Orbiter retrieval) is 36 hours.
  - b. For multiple deployments all payloads are deployed simultaneously.
  - c. There is no retrieval missions.
- 2. For Option 2 and the Final Phase of Option 3:
  - a. For the roundtrip mission the deployment and retrieval are in the same location.
  - b. For dedicated missions the Tug on orbit time is 6 days.
  - c. For multiple deployments, payloads are deployed in the same orbit with 2 revolutions to obtain  $60^{\circ}$  orbital separation.
  - d. For multiple deployments with retrieval, payloads are deployed as above and the retrieved payload is in the same location as the last deployment.
  - e. Rendezvous and docking requires 6 hours.
  - f. Payload spin-up requires 1/2 hour.

ORBIT	NO.	SYM	MISSION	OPTION 1 TIME (1	OPTION 2
Synchronous	(1)	A	Single Deployment	43	43
Equatorial "	(2)	A(2)	Double Deployment	43	91
**	(3)	A(3)	Triple Deployment	43	139
11	(4)	AE	One Deployment - Expend Tug	21	21
	(5)	AB	Roundtrip-Deploy one, Retrieve one	20	43
11	(6)	BA	Dedicated	48	156
11	(7)	A(2)B	Deploy two, Retrieve one	_	91
	(8)	A(2)B	Deploy Three, Retrieve one	-	139
11	(9)	В	Retrieve one	-	43
Low AV	(10)	A	Single Deployment	23	23
High Inclina-	(11)	A(2)	Double Deployment	23	23
tion,	(12)	A(3)	Triple Deployment	23	23
11	(13)	AB	Round Trip	23	23
11	(14)	BA	Dedicated	42	150
11	(15)	A(2)B	Deploy Two, Retrieve One	-	23
**	(16)	B	Retrieve One	-	23
High ΔV	(17)	A	Single Deployment	35	40
Med.Inclination	(18)	A(2)	Double Deployment	35	40
11	(19)	A(3)	Triple Deployment	35	40
17	(20)	ΑE	One Deployment - Expend Tug	15	15
11	(21)	AB	Roundtrip	-	40
11	(22)	A(3)B	Deploy Three, Retrieve One	-	40
***	(23)	В	Retrieve One	-	40
Planetary	(24)	A	Single Deployment	32	32
11	(25)	A(2)	Double Deployment	32	32
11	(26)	AE	One Deployment - Expend Tug	10	10

#### Mission Model Capture

Mission model capture analysis involved the assigning of each payload in the mission model to specific flights. The assignment involved consideration of tug capabilities (availability, payload weight, maneuver capability, and mission duration capability), Shuttle constraints (availability, cargo bay dimensions, payload weight and launch constraints) and payload characteristics (weight, physical dimensions, launch schedule, mission constraints such as DOD mission modes). Payloads were combined to minimize the number of tug flights necessary to perform all of the missions identified in the mission model.

The Flight Summary is shown in Table 2.1-3. Out of 558 missions the Option 3 Tug performs 525 and requires 366 flights to accomplish them. The 33 missed flights are due to the Shuttle limit of 3 Tug missions in 1980 and 21 Tug missions in 1981.

FLIGHT SUMMARY-OPTION TOTAL-OPTION 3

						Calendar	1	Year					
ísi	Flight Mode	80	81	82	83	78	85	98	87	88	89	96	Total
	Shuttle	က	21	22	36	ተተ	41	4.1	04	37	17	04	398
Totals	Tug	3	21	22	36	44	11	41	10	37	Τħ	04	396
	Deploy												
	Single Payload	2	21	18	25	12	17	L.	10	7	12	10	138
	Multi2 Payloads	1		2	8		1	1	5	4	7	٦	27
	Multi3 Payloads				1	2	1	1	1	1	Q	2	11
	Kick-Stage Mode			2	1	2		3 .	S				10
Tug	Expendabl.e					8		1	7		т	7	. 60
Flight Distribution													
	Retrieve	·											
	Single Payload					12	6	12	8	9	8	11	69
	Round Trip												
	Deploy 1/Retrieve 1					13	14	16	11	16	10	15	95
	Deploy Multi/Retrieve l		•			1	1		۲		1		4
	Sortie				٦		п		٦		7		1
	Total												
	Deploy	34	23	24	48	37	37	32	<u>-</u>	375	43	₹	387
Mission Model	Retrieve	0	0	0	1	25	25	28	21	25	20	56	171
	Total	37₹	23	54	64	62	62	99	62	55	63	09	558
Accomplishment	Total	3	27	77	64	62	62	09	62	59	63	09	525

#### ACPS Capabilities - Option 3I

Option 3I ACPS requirements are to provide 3 degree of freedom attitude control and a limited amount of axial  $\Delta V$  capability. The  $\Delta V$  requirement is for propellant settling and payload backoff. The selected monopropellant blowdown system has a thrust range of 27-16 lbs and provides the following control characteristics.

	Pitch/Yaw Acceleration	Roll Acceleration	Pitch Yaw Minimum Limit Cycle Rate	Roll Minimum Limit Cycle Rate
Min	.135°/d <sup>2</sup>	1.78°/s <sup>2</sup>	.002 <sup>0</sup> /s	.027°/s
Max	.581°/s <sup>2</sup>	2.67°/s <sup>2</sup>	.009°/s	.04 <sup>o</sup> /s

≤ 0.1°/s Required

Total impulse requirements for the Option 1 vehicle are 13200 lb sec for attitude control and 34400 for propellant settling giving a total of 47600 lb sec which is well within the 65000 lb sec capacity of the selected ACPS tankage.

#### ACPS Capabilities - Option 3F

Option 3F ACPS requirements are to provide 3 degree of freedom attitude control, 3 degree of freedom translation control, and axial  $\Delta V$  capability. The selected bipropellant system has 100 lb axial thrustors and 25 lb tangential thrusters and provides the following attitude control characteristics:

	Pitch/Yaw Acceleration	Roll Acceleration	Pitch Yaw Limit Cycle Rate	Roll Limit Cycle Rate
Min	.321°/s <sup>2</sup>	2.0°/s <sup>2</sup>	.005 <sup>0</sup> /s	.03 <sup>°</sup> /s
Max	4.0°/s <sup>2</sup>	3.65°/s <sup>2</sup>	.06 <sup>o</sup> /s	.055 <sup>0</sup> /s

≤ 0.1°/s required

#### Translation and $\Delta V$

Axial Acceleration	Lateral Acceleration	Control/Disturbance Moment During Lateral Acceleration
Min .2 ft/sec <sup>2</sup>	, <del>-</del>	-
Max 1.8 ft/sec <sup>2</sup>	-	-
Synch Retrieval		
.34 or $.68$ ft/sec <sup>2</sup>	.17 $ft/sec^2$	6.5:1 (> 2:1 desired)

Total impulse requirements for Option 3F are 73000 lb sec for attitude control and  $\Delta V$  and 85000 lb sec for propellant settling for a total of 158000 lb sec which is well within the 176000 lb sec capacity of the selected ACPS tankage.

#### 2.2 Ground/Onboard Functional Requirements

#### FLIGHT OPERATIONS

Definition of this program option must include a description of the operational functions that must be performed by the associated Tug design/configuration. The operational concept for the autonomy level of this option, developed earlier and modified to be consistent with the latest changes, is included herein. Since the differences between autonomy levels III and IV are minor software variations, the same operational concept applies for both autonomy levels. Also, since all the configurations of the three options are based on either Level III or IV, the concept is essentially identical for all three options. First and second level functional flow diagrams for each of the four reference missions may be found in the Appendix.

Following the operational concept is a brief description of the analysis that was performed to estimate the effort and cost of the operations (recurring and non-recurring) for this option. The summary results of this analysis for both NASA and DOD are shown.

#### OPERATIONAL CONCEPT -- AUTONOMY LEVEL III AND IV

#### LAUNCH AND ASCENT

Orbiter provides environmental control, power, structural attachment and propellant venting and dump lines. Tug remains quiescent with electronic equipment in standby mode.

#### PRE-DEPLOYMENT CHECKOUT

Mission Support Operator (MSO) in the Orbiter activates and checks the Tug subsystems by means of the onboard automatic checkout equipment. The MSO initializes the Tug computer and aligns the Tug IMU. The MSO disconnects the vent and dump lines and releases the stowage retention devices.

#### TUG DEPLOYMENT AND SEPARATION

The MSO rotates the Tug out of the cargo bay to launch position. The MSO connects the manipulator to the Tug, disconnects the umbilicals, releases the base ring attachment devices, moves the Tug away from the Orbiter and releases it. The MSO activates and checks the APS, attitude control and main propulsion by RF link.

The MSO performs post separation subsystem checks by RF link to the automatic checkout equipment. The MSO transfers control to the Tug by RF link. Upon acquiring control, the Tug is programmed to maneuver to a local vertical/orbit plane orientation in preparation for the first main engine burn. An inertial orientation will generally be maintained throughout the mission except for main engine burn periods and when payload thermal requirements dictate otherwise.

#### PHASING, TRANSFER, AND INJECTION INTO ORBIT

The data management system (DMS) receives the propulsion burn parameters from the ground via RF uplink command sequence and executes the commands at the appropriate time to perform the required attitude maneuvers, check the subsystems readiness and make the main engine burn. The velocity increment actually measured along with other pertinent data is reported by RF downlink to Mission Control. Ground tracking and computation will

determine if and when midcourse corrections are necessary between principal burn locations and the degree of correction required. The appropriate burn parameters will be transmitted to the Tug by RF uplink command and executed by the DMS at the designated time.

#### PAYLOAD DEPLOYMENT AND SEPARATION

Prior to arriving at the desired location in the required orbit, Mission Control transmits an uplink command to enable payload deployment. Upon arrival at the desired location, the DMS executes a stored sequence to accomplish the following:

Activate the docking subsystem

Disconnect the payload umbilicals

Spin up the payload if required for stabilization

Release the docking ring latches to uncouple the payload

Fire APS thrusters to provide separation distance

Deactivate the docking subsystem including the spin mechanism.

Upon completion of deployment, the DMS is programmed to report accomplishment to Mission Control. Mission Control then transmits commands to initiate the next phase of the mission operation.

#### RENDEZVOUS AND DOCKING

After the appropriate burns and coast periods to place the Tug within normal rendezvous range of the payload, Mission Control will compare the relative orbital positions of the Tug and payload, as determined by ground tracking, calculate the azimuth from the Tug to the payload and command the proper orientation of the Tug to permit acquisition of the payload by the

rendezvous sensor (laser radar). The rendezvous sensor will acquire and lock on to the payload which is passive. In the event the Tug has no rendezvous sensor, this azimuth pointing is not necessary. Mission Control will ascertain by RF link whether the payload is ready for rendezvous.

The rendezvous sensor provides range, range rate, and angular line of sight data to the data management system which transmits it to the ground for computation of the rendezvous intercept maneuvers and the terminal phase initial burn parameters. Upon receipt of an uplink command sequence, the data management system commands the Tug to maneuver to the required attitude, checks subsystem readiness and commands the APS burn to acquire velocity for target payload intercept. After the designated coast period the data management system will command an APS burn to decelerate the Tug. For the Tug without the rendezvous sensor, the terminal phase initial burn and subsequent deceleration will be determined solely on ground tracking data.

During the coast period, Mission Control will verify the payload readiness for docking by RF link and command activation of the docking subsystem.

The range, range rate, and angular data from the sensor will be used by Mission Control to determine final intercept maneuvers, compute the terminal phase final burn parameters and determine the payload docking mechanism orientation. Without a rendezvous sensor, the final maneuvers and burn parameters must be ground computed from tracking data until docking sensor acquisition is obtained.

During final target closure the docking sensor will determine the docking structure orientation and the APS impulse sequences required to maneuver

the vehicle to a position along the docking axis at the desired precontact range will be commanded. At this point the sensor will verify proper docking alignment and the APS system will maintain this attitude orientation while providing the desired closure velocity through contact. If the payload is spinning, the Tug docking ring is spun up to an equivalent rate before docking occurs.

After contact is established, payload subsystems are passivated and the payload is de-spun by the docking ring drive. When the payload rotation has been sufficiently slowed indexing will be accomplished to stop it in the proper position so that umbilicals can be reconnected. The payload will be safed and configured for return while the Tug is maneuvered to the proper orientation for initiation of the next phase of the mission operation.

#### RENDEZVOUS WITH ORBITER

The Tug will be returned to the proper orbit for rendezvous with the Orbiter and will assume a stationkeeping/passive role during the rendezvous.

After communication is established, Tug control will be transferred to the Orbiter but attitude control will be automatically maintained.

As the Orbiter closes on the Tug, Tug subsystems will be deactivated and safed prior to attachment for retrieval.

When the Tug has been resecured to the base ring and retracted into the cargo bay, the umbilicals and vent lines are reconnected and the Orbiter again provides basic services to the Tug during reentry, descent and landing.

#### 2.3 ORBITAL OPERATIONS COSTS

ORBITAL OPERATIONS COSTS ARE PRESENTED IN THIS SECTION IN TERMS OF MANHOURS AND COMPUTER HOURS FOR THE FOLLOWING WBS ITEMS:

#### PHASES

- WBS 32A DESIGN, DEVELOPMENT, TEST & EVALUATION (DDT&E) PHASE (NON-RECURRING)
- WBS 32C OPERATIONAL PHASE (RECURRING)

#### LEVEL 4

- FLIGHT OPERATIONS, NASA
- FLIGHT OPERATIONS, DOD

#### LEVEL 5 (SAME FOR EACH LEVEL 4)

- MISSION PLANNING
- FLIGHT CONTROL
- FLIGHT EVALUATION
- FLIGHT SUPPORT SOFTWARE

FLIGHT OPERATIONS (NASA)/(DOD)

DDT&E (NON-RECURRING) (32A-11/12)

MISSION PLANNING 32A-11/12-01

FLIGHT CONTROL 32A-11/12-02

FLIGHT SUPPORT SOFTWARE 32A-11/12-04

> PERFORM MALFUNCTION ANALYSIS PREPARE CONTINGENCY PROFILES

DEVELOP FLIGHT MISSION RULES

& SUPPORTING DATA

PREPARE ABORT PROFILES

- TRAINING
- PERFORM OPERATIONS PLANNING &

DEVELOP COMPUTER PROGRAM FOR MISSION PLANNING

DEVELOP COMPUTER PROGRAM FOR FLIGHT CONTROL

DEVELOP FLIGHT OPERATION

SIMULATION PROGRAM

FLIGHT EVALUATION 32A-11/12-03

DEVELOP ON BOARD FLIGHT OPERATION

SOFTWARE

DEVELOP POST FLIGHT EVALUATION SOFTWARE

PREPARE SHUTTLE FLIGHT SUPPORT

SOFTWARE

NOT APPLICABLE

PREPARE SYSTEM SCHEMATICS

FREPARE FLIGHT CONTROL

OPERATIONAL DATA BOOK

- PREPARE INTERFACE DRAWINGS
- PLAN ALL SCHEDULES

PREPARE SYSTEM PROCEDURES &

CHECKLISTS

PREPARE COMMAND HANDBOOK

FREPARE FLIGHT INSTRUMENTA-

TION LIST

# FLIGHT OPERATIONS (NASA)/(DOD)

# OPERATIONS (RECURRING) (32C-11/12)

MISSION PLANNING	32C-11/12-01

## FLIGHT CONTROL 32C-11/12-02

## FLIGHT EVALUATION 320-11/12-03

### FLIGHT SUPPORT 320-11/12-04 SOFTWARE

- TRAJECTORIES, TIMELINE, PREPARE FLIGHT PLAN,
- CONTINGENCY PROFILES PERFORM MALFUNCTION ANALYSIS & PREPARE
- PREPARE ABORT PROFILES
- PREPARE SYSTEM PROCE-DURES & CHECKLISTS
- PREPARE FLIGHT INSTRU-MENTATION LIST

SUPPORT LAUNCH AND TUG

ACTIVATION

OPERATE GROUND TRACK-

ING & COMMUNICATIONS

NETWORK

- PREPARE INTERFACE DRAWINGS
- PLAN ALL SCHEDULES

PERFORM FLIGHT DATA

DETERMINE FLIGHT CON-

TROL REQUIREMENTS

RUN FLIGHT CONTROL

PROGRAMS

- PERFORM POST FLIGHT DATA ANALYSIS REDUCTION
- RESOLVE DATA ANOMALIES
- PREPARE FLIGHT EVALUA-TION REPORT

FLIGHT CONTROL COVERAGE

PERFORM REAL TIME

ANALYZE AND RESOLVE IN-FLIGHT ANOMALIES

SUPPORT PRE-LAUNCH

CHECKOUT

SOFTWARE CHANGES SOFTWARE CHANGES FLIGHT CONTROL

MISSION PLANNING

FLIGHT EVALUATION SOFTWARE CHANGES

# SENSITIVITIES FOR FLIGHT OPERATIONS FUNCTIONS

WBS 320-11/12

WBS LEVELS	AUTONOMY	MISSION	NUMBER OF	PROGRAM	PROGRAM	RENDEZ VOUS	an-Mias
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O ABORT PL LIES	II A	Z A .	N.A.	MULTIPLE	INCREASES	INCREASES	INCREASES
	DECREASES	N.A.	N.A.	N.A.	INCREASES	INCREASES	INCREASES
ے ا	INCREASES	N.A.	N.A.	MULTIPLE	INCREASES	INCREASES	INCREASES
O THSTRUME TATION LIST	N.A.	N.A.	N.A.	MULTIPLE	INCREASES	IHCREASES	INCREASES
O OPERATIC: AL DATA BOOK	INCREASES	N.A.	N.A.	N.A.	INCREASES	INCREASES	INCREASES
O SYSTEM SCHEMATICS	INCREASES	N.A.	#. A.	N.A.	INCREASES	INCREASES	THUREASES
o INTERFACE DRAWINGS	INCREASES N.A.	N.A.	7. X.	MULTIPLE	N.A.	N.A.	N.A.
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CHECKOUL	DECREASES	N.A.	MULTIPLE	N.A.	N.A.	N.A.	
o ACTIVATION	DECREASES	N.A.	MULTIPLE	N.A.	N. N.	1.A.	
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o DATA REI UCTION		TNCREASES	MITTELE	M.A.	N.A.	N.A.	N.A.
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o FLIGHT LVALUATION	· · · · ·	ţ.					
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#### FLIGHT OPERATIONS COST METHODOLOGY

- ESTABLISH A BASELINE CONCEPT
  - 1 DAY MISSION
  - AUTONOMY LEVEL IV
  - 11 YEAR PROGRAM
  - CONFIGURATION 101
- DETERMINED MAN HOUR AND COMPUTER HOUR ESTIMATES
  - EXPERIENCE FROM PAST PROGRAMS

SATURN

THOR DELTA

- TIME AND SKILL/COMPUTER
- MAINTAIN A MINIMUM FLIGHT OPERATIONS CREW (60 MEN) AT HOUSTON FOR NASA FLIGHTS AND A SECOND CREW AT SUNNYVALE FOR DOD FLIGHTS
- REMOVE TRACKING NETWORK COSTS AND ADD NETWORK OPERATIONAL REQUIREMENTS

FLICHT OPERATIONS HOM-RECURRING MANPOWER AND COMPUTER HOURS

# WB8 32A-11/12

COMPUTER HOURS		560	89	560	560	1			•	1	<b>E</b>	•	1		203	415	1,385	104	500	415
DURATION		1 YEAR	2.5 YEARS	2 YEARS	1 YEAR	1 YEAR	1 YEAR	1.3 YEARS	1 YEAR	1.5 YEARS	1 YEAR		1.5 YEARS		1 YEAR	2 YEARS	2 YEARS	1 YEAR	2 YEARS	2 YEARS
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FLIGHT OPERATIONS TASKS	MISE ON PLANNING (32A-11/12-01)	O. MALFUNCTION ANALYSIS	02 ABORT PROFILES	03 MISSION RULES	Ot COMMAND HANDBOOK	05 PROCEDURES AND CHECKLISTS	06 INSTRUMENTATION LIST	OT OPERATIONAL DATA BOOK	08 SYSTEM SCHEMATICS	. 09 INTERFACE DRAWINGS	10 SCHEDULES	FLICHT CONTROL (32A-11/12-02)	OI PLANNING	FLICHT SUPPORT SOFTWARE (32A-11/12-04)	O: MISSION PLANNING	0 FLIGHT CONTROL	SIOITATIONS	O': WILIGHT SIPPORT	OS CONTROL STEPPORT	05 FLIGHT EVALUATION

# FLIGHT OPERATIONS RECURRING MAIPOWER AND COMPUTER HOURS

WB8 32C-11/12

3 1 MONTH/FLIGHT 6/FLIGHT 1 1 YEARS 1 1 YEARS 2 /FLIGHT 2 2 11 YEARS 1 1 YEARS 1 1 YEARS 2 11 YEARS 301 2 6 WEEKS/FLIGHT 5/FLIGHT 6 (16+MT)HOURS/FLIGHT 5/FLIGHT 20 8 HOURS/FLIGHT 8/FLIGHT 20 8 HOURS/FLIGHT 8/FLIGHT 20 8 HOURS/FLIGHT 8/FLIGHT	HS TASKS
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8 HOURS/FLIGHT	
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FLIGHT OPERATIONS RECURING MANPOWER AND COMPOUND HOURS

### WBB 32C-11/12

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## 8 0 S 0

PAYLOAD SPIN UP CAPABILITY NOT REQUIRED 1.0 1.04
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RENDEZVOUS AND DOCKING  NOT REQUIRED  1.0  1.2
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	AUTONOMY	) H Y
LEVEL	CONTROL COMPLEXITY	DEPENDENCE ON GROUND
ΛI	1.0	1.00
III	7.5	.67
H	2.0	.50
I	2.5	.40

9 M K ¥ 0 L

DURATION	DURATION VALUE			
-	8	0	0.7	4.0
<b>X</b>	II		0	0
	2			
	5			
PROGRAM	DURATION (YRS)	11	7	<b>*</b>

3.0 1.4 6.0 2.0	M I S S I O N DURATION (DAYS)	DURATION VALUE
·	S	
	3.0	1.4
	0.9	2.0

DEVELOPMENT P	PHASED DEVELOPMENT
1.0	1.7

## SYMBOLS AND NOMENCLATURE

AD //	Autonomy Decrease Factor for Dependence on Ground
AI	Autonomy Increase Factor for Control Complexity
3	Computer Hours
WO OW	Mission Duration Factor
	Man Hours
M	Mission Time in Hours
NF	Number of Flights
NFRD	Number of Flights with Rendezvous and Docking
PD	Program Duration Factor
ЬР	Phased Program Factor
RD .	Rendezvous and Docking Factor
Sp	Spin-up Payload Capability Factor
¥.	Two Mission

### FLIGHT OPERATIONS WBS 32A-11/12(DOTAE)

## OI MISSION PLANNING

01 - (10,400 MB + 344 CB) AIXRDXSPXPP

02 - (5,200 MH + 68 CH) AIXROXSPXPP

03 - (83,200 MR +344 CH) RDXSPXPP

4 - (10,400 MH + 344 CH) ADXRDXSPXPF

35 - (20,800 MH) AIXRDXSPXPP

5 - (6,240 MH) RDxSPxPP

- (16,640 MH) AIXRDXSPXPP - (10,400 MH) AIXRDXSPXPP - (20,800 MH) AIXRDXSPXPP

(6,240 MH + 43 CH)

02 FLICHT CONTROL

O1 - (3,120 MH) ADKRDKPP

## 03 FLIGHT EVALUATION

(Not Applicable)

## OM FLICHT SUPPORT SOFTWARE

01 - (12,480 MH + 407 CH) NO 02 - (24,960 MH + 830 CH) Adamse

)3 - (62,400 MH + 1,385 CH) ADAMDARDASE

14 - (6,240 MH + 208 CH)

5 - (41,600 MH + 746 CH) AIXRDXSP

56 - (24,960 мн + 830 сн)

### FLIGHT OPERATIONS WBS 32C-11/12 (OPERATIONS)

### O1 MISSION PLANNING

- 01 (519 MH + 6 CH) MDxNF + (104 MH + 1.2 CH) NFRD
- 02 (2080 MH + 31.3 CH) AlxRDxSPxPD
- $03 (173 \text{ MH} + 2 \text{ CH}) \text{ AI } \times \text{ NF} + (35 \text{ MH} + 0.4 \text{ CH}) \text{ AIxNFRD} \times \text{SP}$
- 04 (4160 MH + 172 CH) RDxPDxSP
- 05 (4160 MH) AIxRDxSPxPD
- 06 (2080 MH) PDxRDxSP
- 07 (4160 MH) AIxRDxSPxPd
- 08 (4160 MH) AIxRDxSPxPD
- 09 (4160 MH + 27.3 CH) PD

### 02 FLIGHT CONTROL

- 01 (480 MH + 1 CH) ADXMDxNF + (96 MH + 0.2 CH) NFRDxADxSP
- 02 (960 MH + 5 CH) MDxNF + (192 MH + 1 CH) NFRDxSP
- 03 [(32 + MT) 10 MH + (32 + MT) CH] ADxNF
- 04 [(32 + MT) 10 MH] ADXNF
- 05 (160 MH + 8 CH) ADxNF
- 06 (160 MH + 8 CH) ADxNF
- 07 [(16 + MT) 40 MH + (16 + MT) CH] ADXNF

### **03 FLIGHT EVALUATION**

- $01 (160 \text{ MH} + 10 \text{ HC}) \text{ MD} \times \text{NF}$
- 02 (160 MH + 10 CH) MDxNF
- 03 (640 MH + 2 CH) MDxNF
- 04 (480 MH) MDxNF

### 04 FLIGHT SUPPORT SOFTWARE

- 01 (Mission Planning) 0.10
- 02 (Flight Control) 0.10
- 03 (Flight Evaluation) 0.10

### MISSION CONTROL CENTER

### CENTER

- SAME CONTROL CENTER AS USED FOR SPACE SHUTTLE CONTROL
- DEDICATED COMPUTER FOR DURATION OF TUG MISSION
- MISSION DURATION OF 56 HOURS (28 HOURS PRELAUNCH, 4 HOURS CONTINGENCY, FOR HOLDING, AND 24 HOURS FOR TUG MISSION TIME)

### PERSONNEL

- FLIGHT DIRECTOR
- FIVE FLIGHT CONTROLLERS PER SHIFT REQUIRED FOR TUG SUBSYSTEM STATUS MONITORING STATIONS
  - TRAJECTORY & GUIDANCE (RENDEZVOUS & DOCKING)
  - PROPULSION
  - ELECTRICAL POWER
  - . THERMAL & MECHANICAL
  - DATA MANAGEMENT
- 14 TECHNICAL SUPPORT PERSONNEL PER SHIFT TO RESOLVE IN-FLIGHT ANOMALIES
- TOTAL OF 20 PEOPLE PER SHIFT

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· •• • •	TOTAL PROGRAM DO	SIS			
	NUMBER OF FLIGHT	S =217.			•
	AUTONOMY LEVEL	= 3,7			
	NASA MISSION				
	LAUNCH FROM HTR	<b>37.</b>			
· ••	LAUNCH FROM ETR	=180,0			THE RESIDENCE OF THE PARTY OF T
<del></del>	FLIGHT OFERATIONS	RECURRING CO	STS (NASAON	LY)	· · · · · · · · · · · · · · · · · · ·
		MANHOURS	COMPUTER HOUS	s costs	
** * ** **	MISSION PLANNING	<b>= 3</b> 67317, A	3389,9	9044096.4	
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	FLIGHT SOFTWARE	= 159465.°	2362.3	4891308.0	
-	UNUSED MANHOURS	8146736,1_		3334722,7	
	TOTAL OPE, HOURS	<b>=</b> 1594667,7	23619.8	·	•
	TOTAL OFS, CUSTS	<b>*</b> 35888822.2	9046383,9	44926411,1	
	OPERATIONS PER/ELL	_COSTS # 2.	7034.2		
	FLIGHT OPERATIONS	NON-REGURRING	COSTS (TOTAL	PROGRAM FOR SOTH	OOD THASA)
		MANHOURS	COMPUTER HOL	JRS COSTS	
·			200510	11543 <b>5</b> 27,2	
	FLIGHT CONTROL	<b>52263.9</b>	0.0	1175938.2	
	FLIGHT EVALUATIO	N = 0,0	Ŏ. Ō		
	FLIGHT SOFTWARE			5200963.6	
		R\$ # 709133.7	5130.3		
	The second secon	TS = 15955509.0	1964904.9	17920429.0	

OPTION	* 3		-
TOTAL PROGRAH COS	\$-		
NUMBER OF FLIGHTS	<b>=149.</b> 0		
AUTONOMY LEVEL	<b>*</b> 3,9		
DOD MISSION	· · · · · · · · · · · · · · · · · · ·		
LAUNCH FROM HTR	<b>= 21</b> ,0		
LAUNCH FROM ETR	<b>=128</b> ,0	<u> </u>	
FLIGHT OPERATIONS	RECURRING CO	SIS (DOD ONLY)	
	MANHOURS	COMPUTER HOURS	COSTS
MISSION PLANNING	= 318094 <sub>18</sub>	2709,8	7399735.0
FLIGHT CONTROL	8 396596,2	8923,6	15331655,4
FLIGHT EVALUATION	a 327179,8	3408,2	7848924.6
FLIGHT SOFTWARE	= 124197,1	1671,3	3745026,9
UNUSED MANHOURS	<u>1</u> 48182,6	0.0	2963651,4
TOTAL OPS, HOURS	= 1241775,8	16712,8	
TOTAL MPS, COSTS	= 27944344,8	6400998.0	34345341,9
-OPERATIONS_PER/ELT_	505 <b>TS = 23</b>	0505+7	
FLIGHT OPERATIONS	YOV-REGURRING	COSTS (TOTAL PR	OGRAM FOR BOTH DOD THASA)
	MANHOURS	COMPUTER HOURS	COSTS
-MISSIONPLANNING	-a478764 <sub>1</sub> 4	200410	-11543527,2
FLIGHT CONTROL	<b>52263.9</b>	0.0	1175938.2
FLIGHT EVALUATION	= 0,0	ó.0	0,0
FLIGHT SOFTWARE	_= 178005.2	3122.3	- 5200963.6
TOTAL DDT E HOURS	709133.7	5130.3	
TOTAL DUT E COSTS	15955509.0	1964904.9	17920429.0

### 2.4 Shuttle Interface Requirements

The Orbiter/Tug interface subsystem is composed of the extensions of major Tug subsystems to the Orbiter as are necessary for performing the major preflight, flight, and post flight operations. These operations are:

- o Preflight Ground Testing and Checkout
- o Launch Phase Monitoring
- o Pre-release Checkout
- o Activation of Subsystems
- o Deployment of the Tug/Payload
- o Monitoring in Orbiter Proximity
- o Monitoring during Tug Mission Operation
- o Command/Control in Orbiter Proximity
- o Subsystem Deactivation
- o Retrieval of the Tug/Payload
- o Stowage of the Tug/Payload
- o Passivation and Safing of Tug/Payload
- o Return Flight Monitoring .
- o Safety Provisions
- o Ground Support Interfacing

The Orbiter Tug/interface represents the provisions for mating two major systems -each of which is capable of independent operation when parted in space. While
mated, the Tug is dependent to a degree upon the support capability of the Orbiter
and of the ground through the Orbiter. Although passive during most of the
launch and landing periods, continuous safety and subsystem status monitoring
is sustained by the Orbiter crew.

The Orbiter conducts many missions which do not include the Tug, however, and it is essential that the Tug interfaces produce minimum design and operational impacts upon the Orbiter. In order to minimize these impacts, the Tug ancillary hardware is designed for easy removal and installation. The cabin provisions consist of a dedicated portion of the Mission Specialist Station and multiplexed interfaces with the Orbiter Data Management, computation, and display equipment. This allows accessing and display of Tug subsystem status for monitoring, diagnosis and, through the Tug-unique dedicated panel section, sufficient control to take corrective action.

The interface functions and interface hardware were described in detail in Vol. V, Section 2.4.5 and the design approach, requirements, and characteristics were described in Section 2.5.4.

The principal functions and hardware groups are listed below and are shown in Figure 2.4-1.

The major Shuttle/Tug interface operations and support activities which define the Tug operational support requirements placed upon the Shuttle are shown in Figures 2.4-2 (pre-launch and launch operations), 2.4-3 (on-orbit operations for Tug deployment) and 2.4-4 (on-orbit operations for Tug retrieval). Operational details and timelines are provided in Section 6.5.1, crew activities and functions in Section 5.2, and Shuttle computer support requirements in Section 5.3. The abort operations and the supporting analysis are contained in Section 6 and are summarized in Section 2.5.

### **FUNCTIONS**

- o Operations (listed above and discussed in Section 6.0).
- o Safety (discussed in Volume 7.0).
- o Structural/Mechanical Support (attachments, mountings, manipulation provisions)
- o Fluid/Propulsion Support (fill/drain/vent/purge/abort provisions)
- o Thermal Conditioning Support (temperature control provisions)
- o Avionics Support (electrical/electronics, checkout/monitor/control provisions, with data management, communications, electric power, guidance/navigation/control subsystems)
- o Payload Support (checkout/monitoring, control, caution/warning, safing, electrical power circuits routed through the Tug)

### HARDWARE GROUPS

- o Tug Support Structure (tilt table)
- o Tug Support Attachments (hard points, latches, locks, support frame adapters)
- o Remote Manipulating System (RMS arm is part of Orbiter mechanisms, Tugunique end effector with TV and lighting is charged to Tug support)
- o Fill/Drain/Vent/Purge/Abort Line Assemblies (includes vacuum-jacketed low temperature lines and purging provisions)
- o Fluid Panels and Retraction Mechanisms (purging provisions, locks, actuators, drives, drive controls)
- o Electrical/Electronics Support (instrumentation, sensors, caution and warning circuits, electrical cables/connectors, interface units, junction boxes, test points, inhibit functions/circuits/buses, drive control electronics, TV/lighting)

# SHUTTLE/TUG INTERFACES HARDWARE LOCATIONS

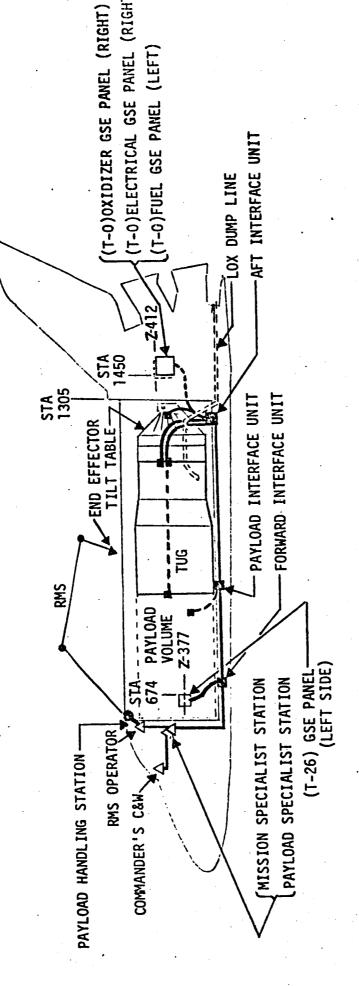


Figure 2.4-1

# SHUTTLE / TUG INTERFACES

### OPERATIONS LAUNCH AND PRELAUNCH

## PRELAUNCH OPERATIONS

### GROUND SUPPORT

- MATE AND VERIFY INTERFACES/ATTACHMENTS
- CHECKOUT TUG SYSTEMS
- PERFCRIS SAFETY CHECKOUT
- PURGE, FILL, DRAIN, VENT TANKS

## SHUTTLE SUPPORT

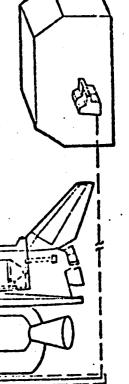
- SHUTTLE/TUG COMPATIBILITY CHECK
- AVIONICS INTERFACE CHECK
- VERIFY CAUTION AND WARNING SIGNALS

### LAUNCH OPERATIONS

- O GROUND SUPPORT
- PERFORM UMBILICAL RETRACTION
- SUPPORT COUNTDOWN AND LAUNCH

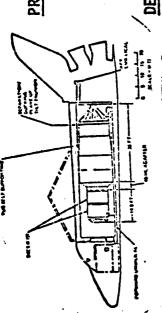
## O SHUTTLE SUPPORT

- PROVIDE FLIGHT MONITORING (C/W)
- SUPPORT TUG SYSTEM MONITORING (PSS/MSS)
  - PROVIDE ELECTRICAL/THERMAL SUPPORT



### S ERFACE z SHUTTLE

## TUG. DEPLOYMEN F O R OPERATIONS 0 N - 0 R B I



## PRE-RELEASE CHECKOUT

- ELECTRICAL/THERMAL SUPPORT
- TUG READINESS CHECKS
- GUIDANCE AND NAVIGATION DATA CHECK/UPDATE/INITIALIZATION

### **DEPLOYMENT**

- FWD UMBILICAL RETRACTION (FLUID CONNECTIONS)
- TILT TABLE CPERATION TO 50 DEGREES
- TUG FUEL CELL PCHERPLANT (FCP) STARTUP
- TUG SYSTEM FULL ACTIVATION AND CHECKOUT
- AFT UMBILICAL RETRACTION (AVIONICS/ELECTRICAL INTERFACES)
- REMOTE MANIFULATING SYSTEM (RMS) OPERATIONS (GRASP, LOCK, TRANSLATE, ROTATE, UNLOCK, RELEASE)

## CO-ORBITAL CHECKOUT

- ACTIVATE ON-BOARD PRESSURE SYSTEMS (1.e., PROPULSION)
- VERIFY SYSTEM PERFORMANCE/FLIGHT READINESS
- VERIFY AVIONICS SYSTEM STATUS/PERFORMANCE
- FINAL UPDATE GUIDANCE/NAVIGATION/CONTROL (GNC) DATA
  - INITIATE TUG FLIGHT AND MONITOR IN ESCORT MODE

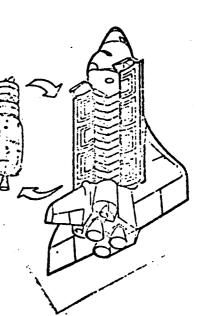
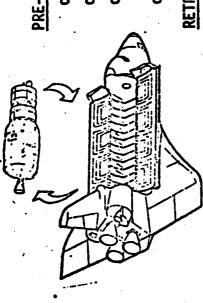


Figure 2.4-3

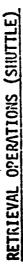
# SHUTTLE / TUG INTERFACES

## 9 1 1 FOR OPERATIONS ON-ORBIT



## PRE-RETRIEVAL OPERATIONS (SHUTTLE)

- D PERFORM RENDEZYOUS MANEUVERS
- MONITOR TUG RENDEZVOUS MANEUVERS TO STAND-OFF POSITION
- CONMARKS PARTIAL SYSTEM DEACTIVATION, CRYOGEN BUMP AND HELIUM PURGE OF TUS TANKS
- O VERIFY TUG SYSTEM STATUS (PASSIVATION & SAFETY)



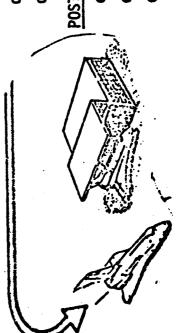
- O APPROACH TUG AND PERFORM STATIC DISCHARGE
- RETRIEVAL OF TUG (PAYLOAD) WITH RAS
- O STOWAGE OF TUG (PAYLOAD) IN PAYLOAD BAY
- RECONNECT MINIMUM UMBILICALS (AVIONICS/ELECTRICAL, FLUID-TBD)
- O VERIFY TUG (PAYLOAD) SAFETY AND SYSTEM DEACTIVATION

## RETURN AND LANDING OPERATIONS (SHUTTLE)

- o PROVIDE RETURN FLIGHT MONITORING (C/W)
- DROVIDE DYNAMIC PROFILE MOMITCRING
- o PROVIDE ELECTRICAL SUPPORT FOR TUG (PAYLOAD)

## POST-LANDING OPERATIONS (GSE)

- O THERITAL CONDITIONING OF TUG AND PAYLOAD BAY (COOL-DOWN)
- O SYSTEM PASSIVATION AND SAFETY VERIFICATION
- O EQUIPMENT/SYSTEM TESTING AND REFURBISHMENT



### 2.5 Abort Analysis Summary

The abort analysis is derived from an assessment of the requirements, constraints and design limitations. The selected abort provisions were described in Volume 5, Section 2.4.5.4 for both suborbital Mode III and Orbital Mode IV, V, or VI aborts. The options considered are discussed in the trade study reported in Section 12.6. The selected options for cryogen handling for both normal and aborted missions are shown in Table 2.5-1.

The timelines are provided for each of the selected abort options in Section 6.1; the shuttle requirements to support these timelines are given in Section 6.2; an altitude versus time analysis is provided in Section 6.3, and analyses of the Delta-V implications of propulsive abort dumping and of the effects of reduced weight during main engine operation are given in Section 6.4

The conclusions reached and a summary of the abort analysis are provided by Tables 2.5-2 and 2.5-3.

### Table 2.5-1 CRYOGEN HANDLING

CONDITION	ro <sup>5</sup>	TH <sup>2</sup>
Normal Mission		
Passivation:	o Keep residual LO2	o Flow residual LH2
(Before Tug capture)	o Vent above 18 psia	through engine down
	-	to 3 psia
Venting:		···P···To · c······· that don co-ristingto-ray-rate durations - to -quinterpolarization-ray-rate-ray-rate-ray-
(After Tug capture/	o Keep residual LO <sub>2</sub>	o Vent again to 3 psia
stowage)	o Vent above 18 psia	o Fill with ambient He to 26.3 psia
		o Vent down to 16±1 psia
	•	o Vent above 18 psia
Aborted Mission		Nominal
Suborbital:	Dump LO <sub>2</sub> to 15 psia:	o Keep LH <sub>2</sub> in tank
(Mode III)	(1) During engine firing,	o Vent above 18 psia
	20% minimum through 3" abort line	Alternative Study Options
	(2) After ET jettison, remainder through 3-inch abort line	o Dump sequentially after LO <sub>2</sub> (CG constraint) <sup>2</sup> down to 110K ft through 4cv 5 inch abort lines o Dump simult. thru 3-In.li
Orbital:	Dump LO to 15 psia:	Preferred-Options 2 & 3F
(Mode IV,V,VI)	Primary Method: (1) During orbital flight,	o Dump under sener
	100% through 2-inch	pressure to 15 psia
	F/D port and tap to 3-inch abort line.	o Keep remainder
	Alternative (Backup)	o Vent above 18 psia
	Method:	Preferred-Options 1 & 3I
	(1) During orbital flight, ~ 40% through 3-inch	pressure to 3 psia .
•	abort line	o Fill with ambient He to 26.3 psia
	(2) During reentry glide, remainder through	o Vent down to 16±1 psia
	3-inch abort line	o Vent above 18 psia
		Alternative (Backup)
	•	o Keep LH <sub>2</sub> in tank
	2-47	o Vent above 18 psia

# ABORT MODE ANALYSIS SUMMARY AND CONCLUSIONS

No dump; continue flight to Modes II or III abort period Mode I

No dump; SRB thrust termination eliminated, SRB separation at 115 sec before dumping is permitted Mode II

(No Mode II abort, as directed by COR instructions).

Start LOX dump at T+116 to T+251 sec; 310 to 280 sec are available before MECO-30, 704 to 649 sec after MECO+30,

Adequate time is available from a 3-inch LOX dump line for Mode III abort. 0

Cryogen dump during engine operation is acceptable according to NASA study directives.

Dump LOX and/or LH2 when liquid/gas interface is relatively stabilized. ٥

Simultaneous dumping is reported to be acceptable when all the following conditions prevail:

- LOX and LH2 outlets are separated by > 300 inches

- Atmospheric pressure > 0.1 psia

- Altitude is > 110,000 ft

Sufficient time exists above 110,000 ft in a Mode III abort for simultaneous LH2 dump with a 3-inch line, including dump time before and after MECO. Sufficient time exists above 110,000 ft in a Mode III abort for sequential  $m LH_2$  dump with a  $^4-$ inch line, including dump time before and after MECO. Insufficient time exists above 110,000 ft in a Mode III abort for  $\mathrm{LH}_2$  dump in stable condition, after MECO.

0

Sufficient time exists above 110,000 ft in a Mode III abort for LH2 dump in variable condition with a 5-inch line. after MECO.

Land full will cause an undesirable reduction of payload capability (-2,051 lb)

CONCLUSIONS:

(1)  $LO_2$  dump is recommended for suborbital abort.

(2) LO2 and LH2 dump is recommended for orbital abort.

Table 2.5-3

## ABORT STUDY ASSESSMENT

			DUMP CRYOGENS	S
	LAND FULL		LO <sub>2</sub> A	LO2 AND LH2
		LU <sub>2</sub> UMLY 3 IN. LINE	SEQUENTIAL 3.5 IN. & 5 IN.	SIMULTANEOUS 3 IN. & 5 IN.
A TUG WEIGHT (LB)	+806	+144	+177	+164
A ORBITER WEIGHT (LB)*	+64	+340	+1303	+1297
A PAYLOAD WEIGHT (LB)				
ROUND TRIP**	-815	-178	-307	-294
GEOSYNCH DEPLOY***	-2015	-489	-938	-903

## LAUNCH FULL, LAND FULL

SAFETY ASPECTS QUESTIONABLE

CANNOT ACCOMMODATE CRASH LOAD FACTORS (ABORT AND CRASH LANDING ARE NOT CONCURRENT

CONDITIONS FOR THIS STUDY)

LANDING CG OUTSIDE OF JSC 07700 PROFILE RANGE

### SYSTEMS

SUBORBITAL DUMP IN MODE III ABURT (T +116 SEC OR LATEK)
SIMULTANEOUS LH2 DUMP AND LQ2 DUMP DEPENDS ON TIME AVAILABLE ABOVE 110K FT
SEQUENTIAL DUMP IS PREFERRED WHEN TIME AVAILABLE, FOR SAFETY MARGIN
SIMULTANEOUS DUMP SAFETY DEPENDS ON ATMOSPHERE PRESSURE AND OUTLET PORT SEPARATION
PAYLOAD WEIGHT IMPACT & CG BENEFIT CONTRIBUTE TO LO2 DUMP PREFERENCE

RECOMMENDATION:

## \* INCLUDES ANCILLARY EQUIPMENT

AWPL = - [AWTUG + 0.1 (AWORBITER)] FOR ROUND TRIP \*

AWPL = - [AWIUG x 2.5 + 0.38 (AWORBITER)] FOR DEPLOY TO GEOSYNCH ORBIT \*\*\*

-2.6 Operational Complexity

Option 3 includes two Tug configurations, an initial and a final. The initial configuration has low performance capability and no retrieval. Lack of rendez-vous, docking, and spin-up capability and short mission duration contribute to a low level of complexity. The number of critical events is low due to limited mission capabilities and duration which also results in low complexity. The low autonomy level (IV) increases complexity but the overall level is considered low.

The final configuration has high performance capability, rendezvous, docking and spin-up capability, longer (six-day) mission duration and a resulting high number of critical events. All of these factors incur high complexity levels as does the low autonomy level (III). The overall complexity level is considered to be high.

### 2.7 KICK STAGE DATA SUMMARY

The use of a kick stage on four of the NASA planetary missions (19, 20, 21 and 23), with both initial and final Tugs, and one DOD mission (11a), with the initial configuration, allows these missions to be flown in a reusable mode with the Tug. These were the only missions where the use of a kick stage was required.

A range of acceptable kick stage sizes was established parametrically for the NASA missions. A survey of existing solid rocket motors was made in an attempt to identify an existing stage which could be utilized for the Tug missions. Several constraints, such as stage length and thrust to weight were used in making the final selection. The stage most nearly meeting the requirements was the second stage of the Polaris A3. This stage is considerably oversized for the DOD mission but can be flown in an off optimum manner. The use of a smaller kick stage was not considered cost effective.

Design details of this stage are classified and may be found in the confidential document Rocket Motors Manual (U), Unit 411, Chemical Propulsion Information Agency, John Hopkins University.

In an attempt to minimize changes to a standard tug/payload interface, the tug/payload/kick stage interface shown in Figure 2.7-1 was conceived. By replacing the standard tug/payload interface truss with the one shown, the tug/payload interface remains the same, with the exception that the interface plane moves forward. The longer struts allow the kick stage to interface directly with the payload interface ring. There is no direct structural interface between the tug and kick stage. The longer struts were designed by the combined payload kick stage loads. Electrical interface between tug and kickstage is accommodated through the tug/payload electrical interface panel. In essence, the kick stage appears as part of the payload to the tug.

Operationally, the Tug separates from the payload/kick stage combination in the same manner as separating from a payload. The Tug provides the proper flight path angle prior to separation. After an appropriate separation distance is established, the kick stage is fired completing the payload velocity requirement. The kick stage must provide thrust vector control during its burn. The tug is then free to return to the shuttle.

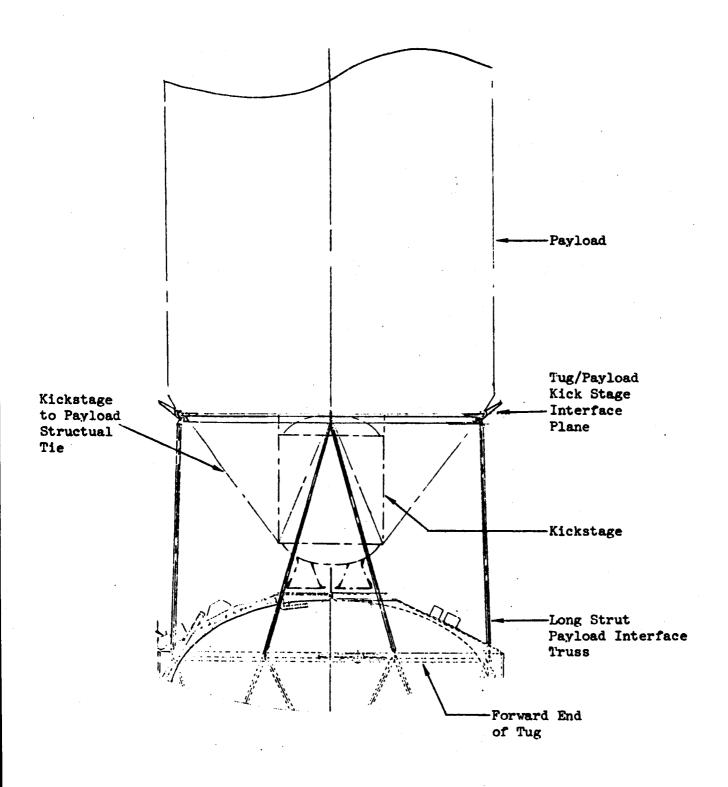


Figure 2.7-1. / TUG/PAYLOAD - KICKSTAGE INTERFACE

### 3.0 ORBITAL OPERATIONS PERFORMANCE DATA (SOFT Panel Format)

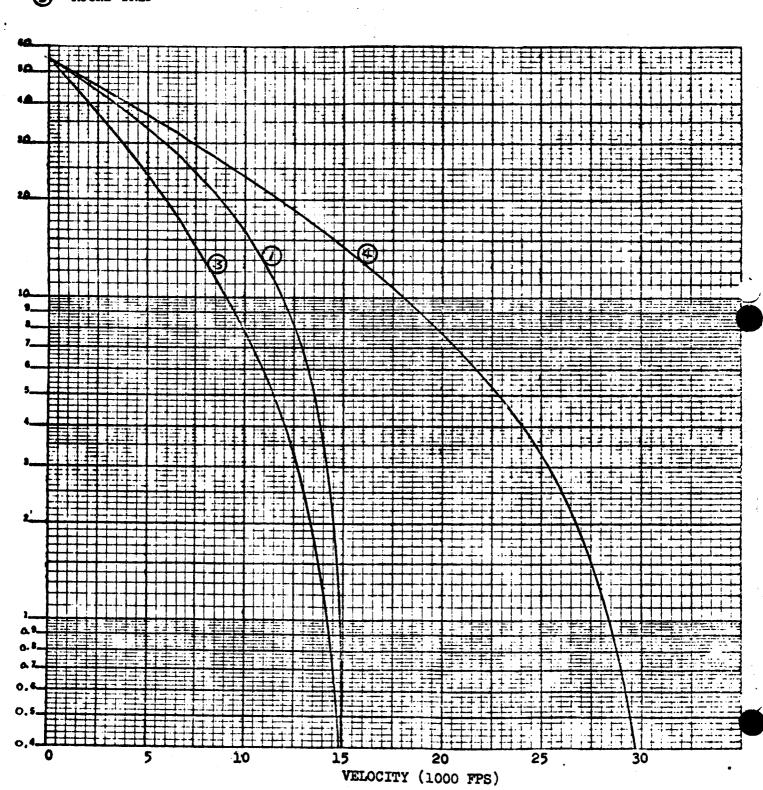
The parametric performance capabilities (payload vs. velocity curves) for three inclinations, 28.5 deg, 55 deg and 90 deg, were determined for each configuration. Option 3I and 3F data are shown in Figure 3-1 through -6 with the other options following in sequence. Additional details of the assumptions and applications pertaining to these data are given in Volume IV, Sections 1.1, 1.3, and 1.4.

configuration 3.7

1 DEPLOY

PAYLOAD (1000 LT

- 2 RETRIEVE
- ROUND TRIP



3-2 Figure 3-1

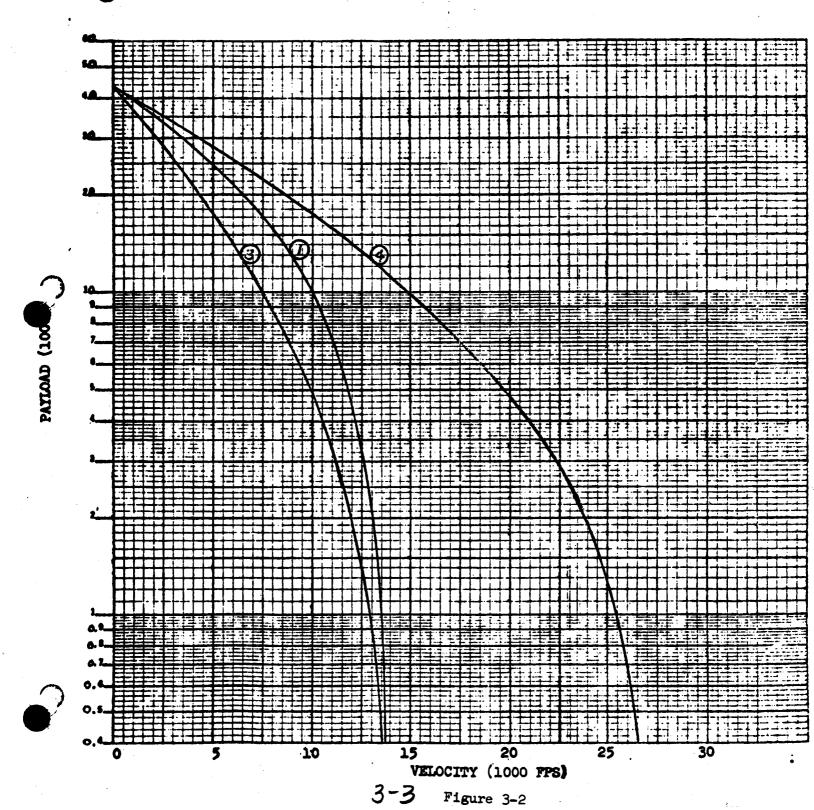
PERFORMANCE CAPABILITY
CONFIGURATION 37

I<sub>SP</sub> <u>441.8</u>

INCL 55°

EXPENDANT

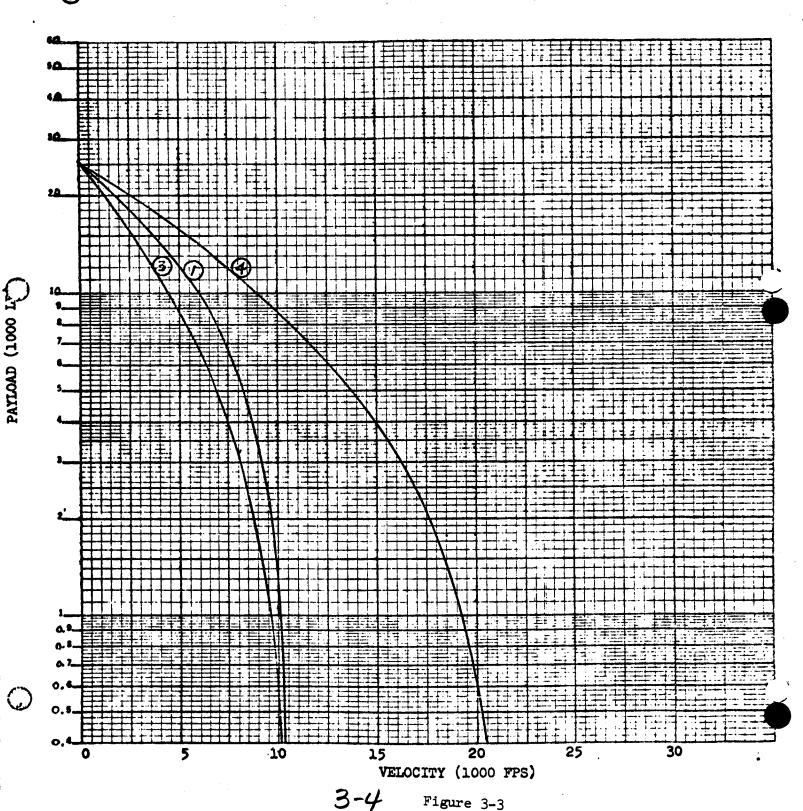
- (1) DEPLOY
- 2 RETRIEVE
- 3 ROUND TRIP



configuration 3T

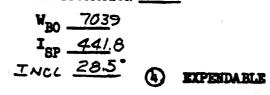
- 1 DEPLOY
- (2) RETRIEVE
- (3) ROUND TRIP

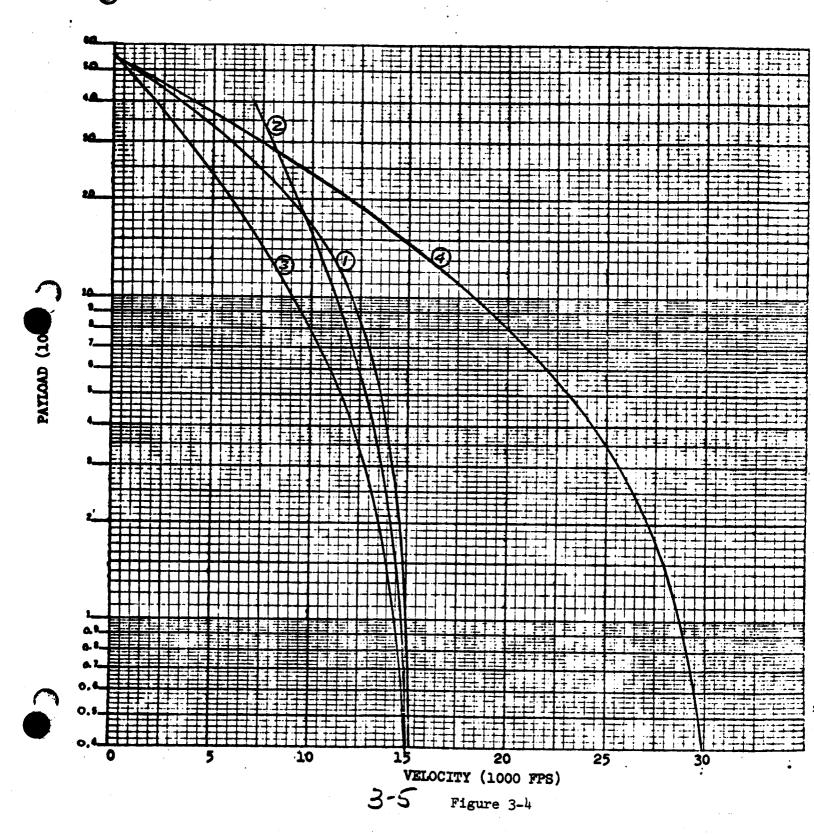




CONFIGURATION 3F

- DEPLOY
- ROUND TRIP



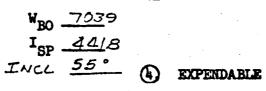


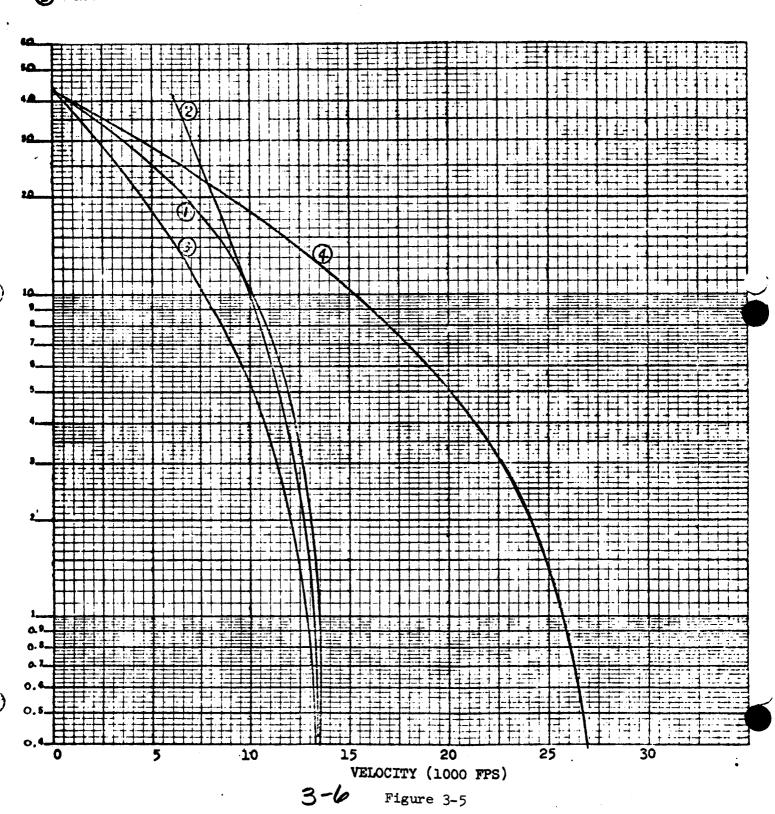
CONFIGURATION 3F

DEPLOY

PAYLOAD (1000 LY

- RETRIEVE
- ROUND TRIP





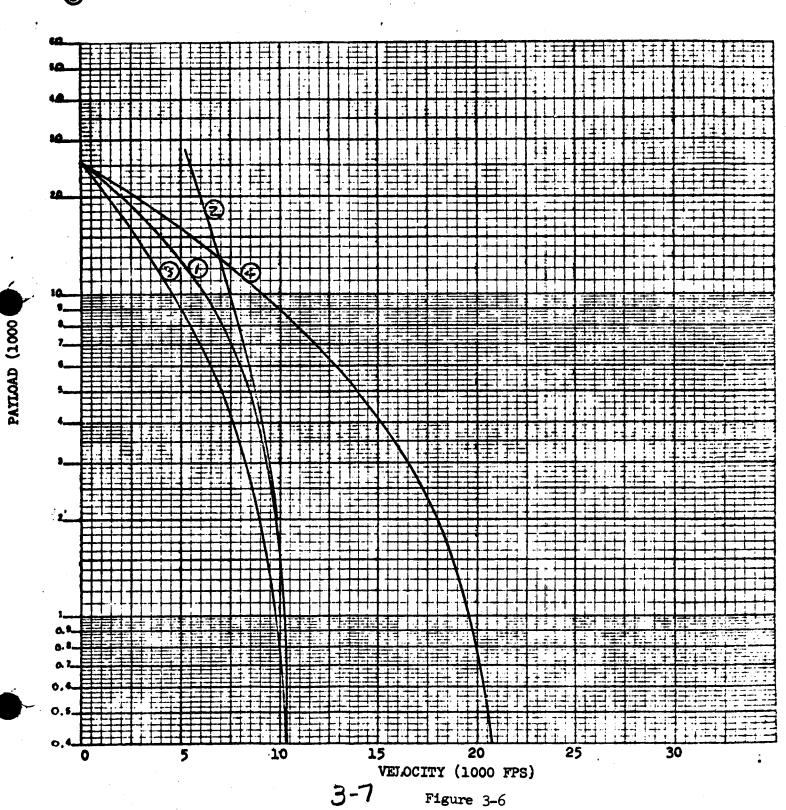
PERFORMANCE CAPABILITY
CONFIGURATION 3F

W<sub>20</sub> 7039.

I<sub>SP</sub> <u>441.8</u>

- INCL 30
- 2 RETRIEVE
- (3) ROUND TRIP

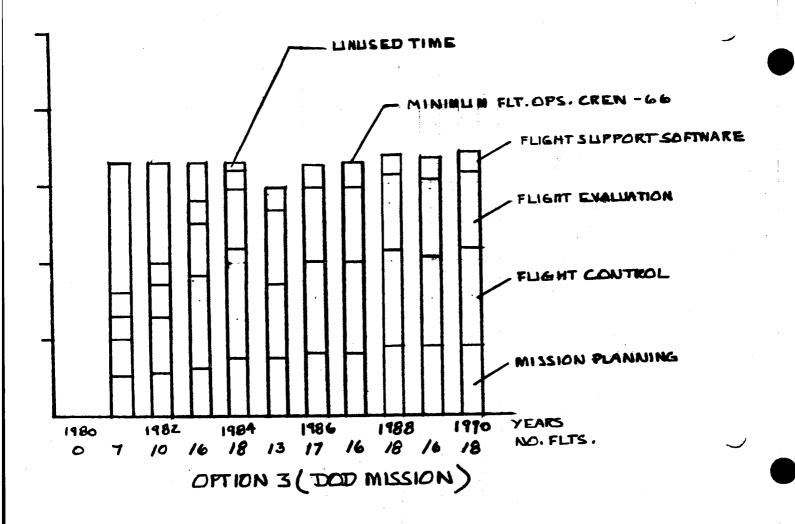
DEPLOY



1.0 Orbital Operations Costs

The flight operational functions are described in the following Flight Operations description sheets, Sections 4.1 through 4.9. Costs are presented in terms of ground support manpower and computer hours in these sheets.

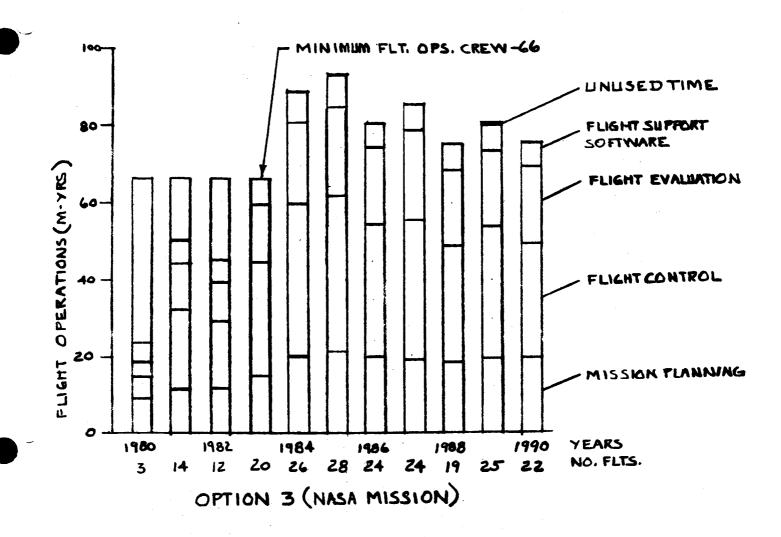
These data as shown in Fig. 4-1 and 4-2 are summarized in this section and are converted to dollars.



TOTAL MANYEARS = 656
MISSION PLANNING = 153
FLIGHT CONTROL = 216
FLIGHT EVALUATION = 157
FLIGHT SUPPORT
SOFTWARE = 60
UNUSED TIME = 70

TOTAL FLIGHTS = 149
WTR FLIGHTS = 21
ETR FLIGHTS = 128

FIGURE 4-1 FLIGHT OPS. MANPOWER REQUIRED



TOTAL MANYEARS = 843
MISSION PLANNING = 186
FLIGHT CONTROL = 313
FLIGHT EVALUATION = 187
FLIGHT SUPPORT
SOFTWARE = 77
UNUSED TIME = 80

TOTAL FLIGHTS = 217 WTR FLIGHTS = 37 ETR FLIGHTS = 180

FIGURE 4-2 FLIGHT OPS. MANPOWER REQUIRED

outral	= 3	and the second section of the second section sec	ter de autoriana de terres en
74,A7	E-1937	erikanalistikan di Tibiran ara	Annual Communication of the Co
CULUER OF FLIGHTS	<b>=</b> 3.9	•	
ALTOHOMY LEVEL	= 4,7		· · · · · · · · · · · · · · · · · · ·
NCIERIN ARAM	and in security of the securit	a kinggantautas da attentionamentales, quintaga paratir da homores de borra. Par es c	THE THE PROPERTY OF THE PROPER
HISBION DURATION	= 43,)		
CAUDON FROM PTR	# 9.0	·	
L/UNGH SFRUM STR			manufacture of an artistic control of the control o
FLIGHT OPERATIONS	RECURRING FO	TTS (ANHUAL)	
	SELOFHAM	COMPUTER HOURS	COSTS
HIGSION PLANNING.	-=1,75 <u>1</u> 5 <sub>4</sub> t	15;,6	439996.4
FLIGHT CONTROL	# 491256.3	221,3	2123870.4
FLIGHT EMALMATION	= 5020,3	63,8	13:919.7
FUIGHT SOLTWARE	12450.	49,0,	33 <sub>0</sub> 753 <sub>4</sub> 4
UBUSED MANHOURS	n 92453,5	0,0	1849059,2
TOTAL 185, HOURS	<b>= 124300,5</b>	432,6	- <del>agunga guyan</del> maninga - <del>alaba</del> n sen sen inflitti (* 70 - 70 - 70 - 70 -
TOTAL UPS. COSTS.		187533,9	2995 <b>53</b> 3.9
DPERATIONS PERVELT	505TS = 99	751 <b>1.3</b>	

. OPTION	<b>3</b>		
YEAR	_a_1384		
NUMBER OF FLIAHTS	= 14.0	·	
AUTONOMY LEVEL	<b>z.</b> 4,9		
NASA MISSION			See The Control of
MISSION DURATION	a 41.1		
LAUNCH FROM WTR	# 0.0		- Angles from the distriction of matter.
LAUNCH FROM ETR	<u> </u>		
FLIGHT OPERATIONS	RECURRING TO	RTS (ANNUAL)	
	SELOFIAM	COMPUTER HOURS	COSTS
MISSION PLANNING	_=26:15+2_	235,3	611466,
FLIGHT CONTROL	74713,4	1007.4	1830210.
FLIGHT EVALUATION	= 24966.4	314,7	642639,
FLIGHT SOFTWARE	12481,4	173.5	378476.
UNUSED MAINIOURS	<b>31220.3</b>	0,0	624436
TOTAL OFS, HOURS	= 1243,0,6	1735,7	
TOTAL OPS. COSTS.	# 2959514.h	564765.1	3472763.

12.3 4.0 40.3 0.0		
40.3		
40.3 0.0		
0.0 12.0		
12.0		
12.0		
		<del>Administration of the state </del>
IEDUKRING GO	ETS CANHUAL)	
RELONAR	COMPUTER HOURS	COSTS
24452,3	221,8	57 <b>3</b> 780 <b>.6</b>
798, 9,6	854.7	1924308.2
20338,1	274,2	514262.8
12403,5	142,9	369394,6
42755,0	n,3	855118,3
124309,0	1495,6	reactioning and the transport of the state o
	573946,2	33512946.2
	24452,3 798,9,6 20338,1 42480,5 42755,9 124300,6	2038,1 275,2 12485,5 142,9

в 3	entrone con a companya and programs as
4-1687	in the first of the community of the constant
= 20,3	
<b>*</b> 4,0	
	erin na sangara é a lata sing été é éngan yay linaka
# 38,4	
# 4,ŋ	• • • • • • • • • • • • • • • • • • • •
<b>4 16.</b> 2	Lagrany rays strangering, ellipsyche sesti as par
RECURRING COSTS (ANNUAL)	
MANAGURS COMPUTER HOURS	COSTS
- 34,377,4 283,4 71	&CU5.8
<b>a</b> 60719,2 1388,1 174	6044.7
<b>=</b> 337, 3, 7 443, 5 64	3922.1
235,0 46	2005,8
a 3 6,0 0,0	6138,4
= 124 <sup>0</sup> , 0, 0 2350, 0	
R_2308:0::4290005a.5370	8853 <b>,5</b>
USTS =	
	= 337, 3,7 443,5 64 = 12480,5 235,0 46 = 3.6,9 0,0 = 1243,0,6 2350,0 = 2328 90053,5 370

*#TIOM	= 3		malamin arakamin di samay masi ili sama'ak ili ili ili ili ili ili ili ili ili il
YEAR	z 1954		This said the said the analysis of the said the
NUMBER OF FLIGHTS	<b>z</b> 26.9		
AUTOHOMY LEVEL	= 3,0	The state of the s	er <del>electronia</del> (errer ) e (escapas erre (g. ) ( g. ) ( g. ) ( g. ) ( e. )
NASA MISSION			more management of a contraction of the contraction
MISSION DURATION	= 39.0		
LAUNCH FROM HTR.	<b>=</b> 4,3		
LAUHCH FROM ETR	= '22.1		
FLIGHT OPERATIONS	RECURRING	TOSTS (ANNUAL)	
	SPUCHNAM	COMPUTER HOURS	COSTS
HISSION PLANNING	42551,	373,2	994067.0
FLIGHT CONTROL	# 79321 <sub>4</sub>	1514.8	2166618,0
FLIGHT EVALUATION	= 44:21,	579,1	1102221.0
FLIGHT SOFTWARE	46585	77	519732.2
UNUMED MANADURS	<b>i</b>	0.0	0.0
TOTAL OPS, HOURS	= 165097,	2741.2	Advisor of the second s
TOTAL SPS. COSTS	3/32493	1049881.4	4782578,1
OPSEATIONS PERZELT	iosts =	133945 . 3	

INDITAC	= 3		
YEAR	= 1985		and and analysis of the second
HE HER OF FLIGHTS	<b>= 28.</b> 9		
AUTONOMY LEVEL	<b>*</b> 3.3		•
NASA MISSION			
HISSION DURATION	<b>= 39.</b> 3		
LAUNCH FROM HTR	= 6.)	(	
LAUNCH FROM ETR	= 22.)		andre and the state and a distance with the second section of the second section of
FLIGHT OPERATIONS	RECURRING COS	TS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
HISSION PLANHING	_=44559_1	392,7	1043585,0
FLIGHT CONTROL	я 34754,9	1612.0	2312485.4
FLIGHT EVALUATION	= 47531.7	623.6	1179484.1
FLIGHT SOFTWARE	= 17641.4	292,0	552963,2
UNUSED MANHOURS	a 5.7	ე. ე	0,6
TOTAL OPS. HOURS	n 176445.8	2922.3	and the property of the second
TOTAL DES. COSTS	3922:22, 4.	1116989.3	5086517.7
OPERATIONS PERFELT	custs = de:	732.8	

,)PT1011	<b>s</b> 3		Bergang (Balang ang Pangang Ang Pangang Pangang Pangang Ang Pangang
YLAR.	-2-1936		
NUMBER OF FLIGHTS	= 24.)		
AUTONOMY LEVEL	<b>=</b> 3,)		
NASA MISSION			
NISSION DURATION	<b>=</b> 36,7		4
LAUNCH FROM RTR	= 4, )		en den der en
LAUNCH FRUM ETR	_= 20		
FLIGHT OPERATIONS	RECURRING CO	DETS (ANNUAL)	
e e e e e e e e e e e e e e e e e e e	SPUCHIAN	COMPUTER HOURS	COSTS
MISSION PLANNING	39385,7	343,1	931056,6
FLIGHT CONTROL	= 71549,3	1370.6	1957929,7
FLIGHT EVALUATION	# 42161,7	525,4	1044475,6
FLIGHT SOFTWARE	-=15760+2-		47,9745,1
UMUSET MANHOURS	<b>x</b> 0,0	2.9	0,0
	= 153697,7	2493,5	initia in ma managata managana ma
TOTAL OPS, HOURS			

UPTION	= 3		
YEAR	E 1987		and the state of t
NUMBER OF FLIGH	TS = 24.0		and the second s
AUTOHOMY LEVEL	<b>= 3.</b> 0		
NASA MISSIUN			allen sig der millere trage deptembere allen selber i sterne geto. V. C. Ser sig er Sterne selber
HISSION DURATION	<b>= 45.</b> 9		
LAUNCH FROM WTR	s 6,1		
LAUNCH FROM ETE	<u> </u>		provincia : - Advida, especializarea - refere - describabilità (h. 1811-ani hance
FLIGHT OPERATION	IS RECURRING COST	S (ANNUAL)	
<u> </u>	MANHOURS (	COMPUTER HOURS	COSTS
HISSION PLANHING	<u>s_41182,1</u>	357,3	96,561,5
	m 765(6,2		
	N # 45252.2		
UPUSEO MARHOURS		0.0	
TOTAL OPS. HOU	RS = 1,32741,5	2677,5	
	IS 3553411.		
	LT COSTS = 193		

OPTION	<b>#</b> 3		
YEAR	= 1960		and the second s
NUMBER OF FLIGHTS	= 19.0		
AUTONOMY LEVEL	z 3.0		
NASA _MISSION			Makaka proporting nganggang samis angga pakapan na pi s s te s mis manan 1980 s sami
HISSION DURATION	<b>48.6</b>		
LAUNCH FROM WTR	= 4,0		na angang mangganggang ang ang ang ang ang ang ang
LAUNCH FROIL ETR	<b>a 15,</b> 2		allendring allendring regions in the construction of the construct
FLIGHT OPERATIONS	RECURRING GOS	TS (ANNUAL)	
and the second s	MANAGURS	COMPUTER HOURS	COSTS
HISSIONPLANNING	37798,7	32:,7	882821,1
FLIGHT CONTROL	= 59742,7	1147.0	1636653.0
FLIGHT EVALUATION	= 42217,5	453,3	1031947,8
FLIGHT . SOFTWARE	z 14.76.5	213,5	433704,0
UPUSED MANHOURS	3,6	5.0	c, o
TOTAL MPS. HOURS	= 145765,8	2135,5	and an experimental survey of the second sec
A STATE OF THE STA		the state of the s	

PTION	<b>3</b> 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
YEAR			
AUTOHOMY LEVEL	•		Namen a de missionales e estados de la companya del la companya de
HISSION DURATION			<u>.</u> 2
LAUNCH FROM NTR		·	
FLIGHT OPERATIONS		ANNUAL)	
MISSION_PLANNING_	MANHOUPS COMP	*	COSTS 957440.5
FLIGHT CONTROL	z 70^12,7	1328,2	1916958.8
FLIGHT EVALUATION FLIGHT SOFTWARE		•	1053541,5
UNUSED MANHOURS	m G.ŏ	0.3	0,6
TOTAL OPS. HOURS		2472,2 946841,9	4467097.9
OPERATIONS PERVELT	COSTS = 176283	.9	

PTION	a 3	
YFAR	= 10 <del>9</del> ;	
NUMBER OF FLIGHTS	<b>22.</b> 0	
AUTOHOMY LEVEL	<b>m</b> 3,0	
NASA MISSION		
HISSION DURATION	= 37,5	
LAUNCH FROM HTR	= 4,6	
LAUNCH FROM ETR	r_16.0	
FLIGHT OPERATIONS	RECURRING COSTS (AN	NUAL)
	MANHOURS COMPUT	ER HOURS COSTS
HISSION PLANUING	s 41463.2	343.1 9631C1.3
FLIGHT CONTROL	s 59844 <sub>15</sub>	1060,7 1603115.0
FLIGHT EVALUATION	± 4129°, 8	484,6 1011563,5
FLIGHT SOFTWARE	-= -1.4263,1	_21;_4437150,9
UNUSED MANHOURS		
UNUSED MANHOURS	= 142531,2	The second secon

	•				
<del></del>	OPTION	<b>3</b>		• • • • • • • • • • • • • • • • • • • •	
<b>.</b> .	TOTAL PROGRAM COS	IS.			
	NUMBER OF FLIGHTS	=217.1		•	
	AUTONOMY LEVEL	<b>= ₹.</b> ŋ			
	NASA MISSION				·
-	LAUNCH FROM HTR	<b>37.</b> 6			•
•.•	LAUNCH FROM ETR	=18C.0			
<del></del>	FLIGHT OFERATIONS	RECURRING CO	TE (NASAONLY	)	
		• *	COMPUTER HOURS	COSTS	
	MISSION PLANNING	= 3673 7 <sub>+</sub> 8	3389,9	9044096,4	
	FLIGHT CONTROL	= B19:41,0	13000,4	21359978,5	
	FLIGHT EVALUATION	z 398313,5	4869,5	9631028,2	
•	FLIGHT SOFTWARE	= 159466,P	2362,0	4891308.0	
	_UNUSED MANHOURS	146736,1		1334722,7	
	TOTAL OFF. HOURS	<b>=</b> 1594667,7	23619,8		
	TOTAL OFS. COSTS	* 35880327.2	9046388,9	44926411,1	
	OPERATIONS PER/ELI	costs = 2	7034+2		
	FLIGHT OPERATIONS	YOV-REGURRING	COSTS (TOTAL PI	ROGRAM FOR BOTH DOD	HASA)
		MANHOURS	COMPUTER HOURS		
	MISSION PLANNING-	a478264 <sub>16</sub>	2000,0	-11543527,2	
	FLIGHT CONTROL	<b>=</b> 52263.9	0.0	1175938.2	
	FLIGHT EVALUATION	i = 0,0	0.0	0,0	
	FLIGHT SOFTWARE	•	3122.3	5200963.6	
	TOTAL DOT E HOUF		5130.3		
	TOTAL DUT E COS		1964904.9	17920429.0	
		•	•		

• OFTION	R 3
YEAR	· 1961
NUMBER OF FLIGHTS	
AUTONOMY LEVEL	
HISSION DURATION	
LAUNCH FROM HTR	■ 0.0
LAUNCH FROM ETR	<u> </u>
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)
The second secon	MANHOURS COMPUTER HOURS COSTS
MISSION PLANNING	= 355.8,6 181,8 461789,6
FLIGHT CONTROL	= 92282,1 493,8 2634916,9
FLIGHT EVALUATION	= 112(1,6 155,6 298699,2
FLICHT SOETHARE	R 1246:, 5 92,5 347412,9
UNUSED MARHOURS	× 70 076.7 2,0 1417534,3
TOTAL OPS. HOURS	= 1.248¢%,6 924,6
	# 28085 . 354125,6 3102123.6 31021220.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.0 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102120.6 3102100.0 3102100.0 3102100.0 3102100.0 3102100.0 310210

OPTION	<b>3</b>		
YEAR-	= 1 <sup>9</sup> 8?		
NUMBER OF FLIGHTS	= 16.0	· ·	
AUTONOMY LEVEL	= 4.0		• · · · · · · · · · · · · · · · · · · ·
DOD MISSION			
MISSION DURATION	= 39,8		· .
LAUNCH FROM WTR	= 0.0		
LAUNCH FROM ETR	z 10.0		
FLIGHT OPERATIONS	RECURRING COSTS (	ANNUAL	
	MAILHOURS COMP	UTER HOURS	COSTS
MISSION PLANNING	= 22395,5	205,6	536639,6
FLIGHT CONTROL	= 84377,2	707,3	1968440,5
FLIGHT EVALUATION	# 17927,3	224.0	426355,2
FLIGHT SOFTWARE	12483	125,3	355381.7
UNUSED NARHOURS		•	
TOTAL OPS. HOURS	# 124°ad, 8	1263,2	· · · · · · · · · · · · · · · · · · ·
	= 2318° 4.8	1 2	

•	·		
OFTION	3 7 9		
YEAR	× 1983		
NUMBER OF FLIGHTS	= 16.0 17		
AUTONOMY LEVEL	<b>= 4.</b> 0		
DOD MISSION			
MISSION DURATION	<b># 42.9</b>		
LAUNCH FROM WTR	# 4.0		Managaran and an addition of the second seco
LAUNCH FROM ETR	<u> </u>		Divinish China Balakana in a managada na matata
FLIGHT OPERATIONS	RECURRING COSTS	(ANNUAL)	
and the second s	MANHOURS CO	MPUTER HOURS	COSTS
MISSION PLANNING	E 27571,5	255.3	651192,6
FLIGHT CONTROL	a 69263.6	1178.6	1836647.4
FLIGHT EVALUATION	= 27065.5	365,7	697736,3
FLIGHT SOFTWARE		200-1	388619,6
UNUSED MANHOURS	a 18629.5	0.0	372590,5
TOTAL OPS. HOURS	124300,0	2000.5	
TOTAL OPS, COSTS	# 29083.A.A	766195,9	3574195,9
OFERATIONS PERZELT	COSTS = 22338	7,2	

OFT (01)	<b>z</b> 3		
YFAR	я 1294		an managaman ana sari a managa a companya a
NUMBER OF FLIGHTS	= 18.0		•
AUTONOMY LEVEL	= 4,0		
NUISSIUM GOO			
MISSION DURATION	# 40 <sub>1</sub> 6		
LAUNCH FROM HTR	= 1,0		
LAUNCH FROM ETR	= 17,		
FLIGHT OPERATIONS	RECURRING CO	STS (ANNUAL)	
A CONTRACTOR OF THE PROPERTY O	ZELOHIAN	COMPUTER HOURS	COSTS
HIGSION PLANNING	= 3,584,3	283,5	721027.9
FLIGHT CONTROL	<b>a</b> 63335,5	1297,1	1765279,2
FLIGHT EVALUATION	= 32927.7	405,7	771959,1
FILTHIT SOFTWARE	12480,	221,1	396596,3
ULUSED MANHOURS	4453,2	3,0	69064.6
TOTAL OPS. HOURS	= 124810,0	2211,4	and the second of the second s
TOTAL CAPE COSTS		846962.5	3,634,962.5
OPERATIONS PERMIT	COSTS = 22	302 <b>3.5</b>	

OFTION	<b>a</b> 3
YEAR	#- 1935
NUMBER OF FLIGHTS	<b>4 13.</b> 0
AUTOHOMY LEVEL	
Doughtston	
MISSION DURATION	<b>= 48.5</b>
LAUNCH FROM WTR	<b>2.</b> 0
LAUNCH FROM ETR	à 11.2
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)
	MANHOURS COMPUTER HOURS COSTS
MISSION_PLANNING	= 32143,3 261,4 743089,6
FLIGHT CONTROL	<b>a</b> 40122,1 765,9 1095789,3
FLIGHT EVALUATION	a 39255,4 300,9 953853,5
FLIGHT SOFTWARE	<u> 11152,6</u> 143,6 335721,9
UNUSED MANHOURS	w 0,0 0,0
TOTAL OPS. HOURS	<b>2</b> 111526,3 1485,8
TOTAL OPS. COSTS_	# 23:2342,6 569061,0 3076403,6
OPERATIONS PERZELT	30STS = 2348 <b>00.3</b>

*DPT10N	3	
YEAR -	a-1-164	nggagana, salap san philipalise links on the desire. — the
NUMBER OF FLIGHTS	<b>= 17.</b> 0	
AUTONOMY LEVEL	a 3,7	
DOD HISSION		مدار «مادانگار» به ۱۹۰۰ کی کنده از در از ۱۹۰۰ مهمیکارشاند <del>ن داندانگار</del>
HISSION DURATION	s: 36,4	
LAUNCH FROM HTR	ສ	
LAUNCH FROM ETR	= 12,0	Brank all again development ("Net our enterprise our
FLIGHT OPERATIONS	RECURRING MOSTS (ANNUAL)	
A STATE OF THE PARTY OF THE PAR	MANHOURS COMPUTER HOURS	COSTS
NISSION PLANNING	z 36365v4 302 <sub>v</sub> 3	843084,7
FLIGHT CONTROL	± 45192.2 653.2	1270635.8
FLIGHT EVALUATION	a 38489,9 371,3	906329.7
FLIGHT SOFTWARE	3	371845.7_
UNUSED MANHOURS	# 5,8 540	0.0
TOTAL OPS. POURS	= 122741,1 1695,3	The second section of the section of
TOTALCPSCOSTS_	n 2761 272, 6 649754, 3	3411586,9
CPERATIONS PERFET	COST3 # 2006 <b>%1.6</b>	

• 0FT10N		· · · · · · · · · · · · · · · · · · ·
YEAR	= 1987	in die Bereiche der Steine der Gestellen der Bereiche der
NUMBER OF FLIGHTS	m 15.0	
AUTONOMY LEVEL DOD MISSION		
HISSION DURATION		
LAUNCH FROM WTR		
	RECURRING COSTS (ANNUAL)	van de de verte (n. j. de 1 - Paris Alle et l'Indian de 1 - Carre
	MANADURS COMPUTER HOURS &	OSTS
HISSION_PLANNING	2 35462,5 293,3 822	114.8
FLIGHT CONTROL	4 43948,9 925.0 1331	341,3
FLIGHT EVALUATION	<b>a</b> 43737,5 378,3 959	546.2
FLIGHT SOFTHARE	x 12517,2 175,8 33¢	659,1
UNUSED MANHOURS	<b>■</b> 0.0	3.6
TOTAL OPS. HOURS	# 125178,8 1766,4	y tang may mandatan nganang garanagan an antananggan.
TOTAL GES, LOSTS	.= 2816369,5 677291,9 3423	661,4
OFBRATIONS PERZELT	gosts = 210353.8	

OPTION	<b>z</b> 3		<i>t,</i>
YFAR	-n- <u>1989</u>		Hairin alina vigariyara qar ista iyoti isti qaraqa istabiyi.
NUMBER OF FLIGHTS	<b>4</b> 13,6		``
ALTONOMY LEVEL	# 3,g		
Drad HISSION			
NOITAFUR NOISZIM	<b>39.1</b>	·	
LAUNCH FROM WTR	= 2,0		
LAUNCH FROM ETR	= 15.0		
FLIGHT OPERATIONS	RECURRING O	OFTS (ANNUAL)	
and the second s	MANHOURS	COMPUTER HOURS	COSTS
HISSIONPLANHING	38-02-7	314,6	881738,6
FLIGHT CONTROL	z 50331,1	888.9	1347077,3
FLIGHT EVALUATION	= 39533,5	401,2	944330.0
FLIGHT SOFTWARE	= 12792,7	173,3	388107.5
UNDSED MANHOURS	n 19.0	7.0	0.0
TOTAL OPS, HOURS	# 127725,0	1784.0	entagram, gata entaglab en and aller ages en en eller en de de r
TOTAL DPS COSIS	.a2373753,2	692797,7	3531252.9
OFERATIONS PER/FLT		97347.4	

•	· · · · · · · · · · · · · · · · · · ·		
OPTION	s 3		h managadhanni i dan haga dhaga an cunga i si is i i i i su shi h
YEAR	= 1930		
NUMBER OF FLIGHTS	= 16.3		
AUTONOMY LEVEL	<b>4</b> 3.0		and the second control of the second
DOD MISSION			and the second of the second o
MISSION DURATION	= 51.2		
LAUNCH FROM WTR	= 4.0		
LAUNCH FROM ETR	± 12.0		
FLIGHT OPERATIONS	RECURRING CO	RTS (ANHUAL)	
	SEUCHNAM	COMPUTER HOURS	COSTS
HISSION PLANNING	36221,5	295.9	837904,5
FLIGHT CONTROL	# 48483 <sub>1</sub> 7	919,3	1318312,8
FLIGHT EVALUATION	E 41041.0	380,6	935653,8
FLIGHT_SOFTWARE	<b>z</b>	177,2	384250.7
UNUCED MANHOURS	4.6	3.0	0.0
TOTAL OPS. HOURS	= 126554,2	1771,9	n, njegovorgovija vilikali dibajih izmendali († 1. 1916. 1919.
TOTAL OPS . COSTS	<del>294745</del> 1	673453-1	3526121,9

OFTION	3
YFAR	s_199
NUMBER OF FLIGHTS	<b>* 18</b> , q
ALTONOMY LEVEL	s 3,3
pnp HISSION	
MISSION DURATION	= 40.7
LAUNCH FROM HTR	= 1.7
LAUNCH FROM STR	=-17-
FLIGHT OPERATIONS	RECURRING MONTS (ANNUAL)
	MANIOURS COMPUTER HOURS COSTS
HIGGIONPLANNING	= 38.33.4 314.3 831153.6
FLIGHT CONTROL	# 508/2.3 905.4 1363214.6
FLIGHT EVALUATION	
FLIGHT SOFTWARE	189,7 391331,9
	# 0,0 0,0
TOTAL MES HOURS	= 123343,4 1807,4
	692233,5 3571210,7
OPERATIONS PERFELT	505TS = 197511.7

TOTAL PROGRAM COS	TS:			
NUMBER OF FLIGHTS			•• /	
AUTONOMY LEVEL	<b>*</b> 3,9			
DOD MISSION				
LAUNCH FROM HTR	<b>= 21,</b> 0			
LAUNCH FROM ETR	<b>=128,</b> 0			
FLIGHT OPERATIONS	RECURRING CO	SIS (DOD ONLY)	)	
	MANHOURS	COMPUTER HOURS	COSTS	)
MISSION PLANNING	= 318094,A	2709,8	7399735.0	
ELIGHT CONTROL	g 396596,2	8923,6	15331655,4	
FLIGHT EVALUATION	a 327179,A	3408,2	7848924,6	W.
FLIGHT SOFTWARE	= 124197,1	1671,3	3745026,9	
UNUSEDMANHOURS	= 148182,A		2963651,4	
TOTAL OPS. HOURS	m 1241775,9	16712.8		
TOTAL OPS, COSTS	= 27944344,6	6400998.0	34345341,9	<u> </u>
OPERATIONS_PER/FLT	costs . 23	05C5.7		
FLIGHT OPERATIONS	NON-RECURRING	COSTS (TOTAL PR	ogram fo <b>r both</b> i	DOD FNASA)
	MANHOURS	COMPUTER HOURS	COSTS	
MISSIONPLANNING	478264.6	2005,0	11543527,2	
FLIGHT CONTROL	52263.9	0.0	1175938.2	
FLIGHT EVALUATION	* ~	0.0	0.0	
FLIGHT SOFTWARE	178005.2	3122.3	- 5200963.6	
TOTAL DDT E HOURS	<b>7</b> 09133.7	5130.3		
TOTAL DOT E COSTS	<b>1</b> 5955509.0	1964904.9	17920429.0	

# FLIGHT OPERATIONS, OPTION 3 - LATE IOC

The Work Breakdown Structure for the Tug Study divides the flight operations into four areas or blocks, namely: Mission Planning, Flight Control, Flight Evaluation, and Flight Support Software. In order to develop a means of assessing the relative complexity of flight operations for various Tug configurations, it was first necessary to adequately define flight operations. This was accomplished by analyzing the four WBS blocks to determine the specific tasks required in each. These tasks fell into three categories: one time efforts completed prior to the first operational flight, a continuing level of effort for the operational life of the program, and those efforts performed once for each flight. The one time efforts were considered to be part of the DDTAE activities (32A) while the continuing and per flight efforts were assigned to the Operations activities (32C). With this format developed, a reference configuration was chosen (Number 101) and an estimate was made of the manhours and computer time required to accomplish each flight operations task considering the specific characteristics of that configuration.

With the reference configuration estimates determined as a point of departure, it was necessary to establish criteria or a rationale for assessing the operational workload differences between configurations. An analysis of this area concluded that the workload was proportional to the overational complexity of the configuration and the mission. It was also decided that the configuration complexity could primarily be measured by autonomy level and the mission complexity by mission duration. Since the reference configuration was autonomy Level IV (completely dependent on ground support/simple onboard equipment), Level IV was given a reference value of 1.0 and the other levels given relative values to reflect the degree of difference. When autonomy level was used to measure workload related to ground support dependence, the workload decreased with increasing autonomy levels and values were assigned as shown below. It was assumed that ground support effort would not be charged to highly autonomous configurations not requiring that support even though experience indicates that it may be required for some other reason. Some task workloads are proportional to the complexity of onboard equipment and therefore increase with increasing autonomy levels. (Level II was considered the highest level because of the additional mission planning capability.) Values were also assigned as shown below:

AUTONOMY LEVEL	FOUIPMENT COMPLEXITY VALUE	DEPENDENCE ON GROUND SUPPORT VALUE
IV	1.0	1.00
III	1.5	.67
r	2.0	.50
II	2.5	.40

Since the reference configuration was a minimum (1 day) mission configuration, a reference value of 1.0 was given to the 1 day duration and the other durations were assigned relative values as follows:

### MISSION DURATION

DAYS	VALUE
1	1.0
1.5	1.1
3	1.4
6	2.0

Assignment of these values take into account the fact that a configuration capable of longer duration missions does not fly all long duration missions and the average mission length is actually shorter. To obtain a more precise assessment of the effect of mission duration, actual mission time in hours for each flight can be used in lieu of the single mission duration factor value above.

Some tasks must be performed for each flight and, therefore, the reference configuration estimate (per flight) must be multiplied by the number of flights.

For those configurations where phasing occurs from an initial to a final configuration, the continuing level of effort tasks were factored for the number of years the configuration is to be operational. Since the total operational program is eleven years and the configurations are operational for either four, seven, or eleven years, the following values were assigned:

### PROGRAM DURATION

OPERATIONAL YEARS	VALUE
11,	1.0
7	0.7
14	0.4

While the program duration factor proportions the effort between two phased configurations, it does not take into consideration that many of the efforts completed for the initial configuration must be repeated for the final configuration. To take this into account a factor was established as follows:

## DEVELOPMENT PROGRAM

DIRECT DEVELOPMENT VALUE

PHASED PROGRAM. VALUE

1.0

1.7

Since the reference configuration did not have retrieval capability additional complexity is introduced by those configurations having rendezvous, docking and payload spin up capability. Appropriate values were assigned to these factors:

RENDEZVOUS AN	D DOCKING	•	PAYLOAD SPIN-U	P CAPA	BILITY
NOT REQUIRED	REQUIRED	,	NOT REQUIRED		REQUIRED
1.0	1.2	. '	1.0		1.04

With all the complexity factors defined, an assessment was made for each task to determine which factors affected the effort required relative to the reference configuration and how they varied. A summary matrix of the tasks and factors is shown on a following page.

Using the manhours and computer hours estimated for the reference configuration and applying the appropriate factors to each operations task, equations were prepared which could be computed and summed to provide the total flight operations effort for any Tug program or configuration. A computer program incorporating these equations was developed to provide maximum flexibility in determining flight operations efforts for various programs and trade studies. Separate manhours, computer hours and dollar costs are computed for each WBS element (Mission Planning, Flight Control, Flight Evaluation and Flight Support Software) in the DDT&E (WBS 32A) and the Operations (WBS 32C) areas. The Operations estimates are computed for each year of the operational program and totaled. The NASA and DOD figures are computed separately.

# SENSITIVITIES FOR FLIGHT OPERATIONS FUNCTIONS

TBS 320-11/12

WBS LEVELS	AUTONOMY LEVEL	MISSION DURATION	IUNCER OF FLICHTS	PROGRAM DURATION	PROGRAM PHASING	RENDEZVOUS & DOCKING	SPIN-UP
MESSION PLANNING (320-11/12-01)							
FLICHT PLAN	N. A.	INCREASES	andiancy	11.A.	I.A.	INCREASES	M.D.
o MALFUICTION ANALYSIS	INCREASES	K.A.	ii. A.	MULTIPLE	LICHEVSES	LICHERSES	Lichenses
o ABORT PROFILES	INCREASES	N. A.	SOLTIPLE	N.A.	INCREASES	INCREASES	INCREASES
o MISSION AUES	N.A.	.i.A.	N.A.	MULTIPLE	INCREASES	INCREASES	INCREASES
o command Handbook	DECREASES	и.А.	N.A.	N.A.	INCREASES	INCREASES	INCREASES
o PROCEDURES AND CHECKLISTS	INCREASES	N.A.	й.А.	MULTIPLE	INCREASES	INCREASES	INCREASES
O INSTRUCTMENTATION LIST	M.A.	N.A.	и.А.	MULTIPLE	INCREASES	INCREASES	INCREASES
o OPERATIONAL DATA BOOK	INCREASES	ï.A.	N.A.	N.A.	INCREASES	INCREASES	INCREASES
o SYSTEM SCHEMATICS	INCREASES	N.A.	N.A.	H.A.	INCREASES	INCREASES	INCREASES
O INTERFACE DRAWINGS	INCREASES	N.A.	N.A.	MULTIPLE	INCREASES	INCREASES	INCREASES
o SCHEDULES	N.A.	N.A.	N.A.	MULTIPLE	N.A.	N.A.	N.A.
FLIGHT CONTROL (320-11/12/02)							
O CONTROL REQUIREMENTS	DECREASES	INCREASES	NULTIPLE	N.A.	3.A.	INCREASES	INCREASES
c CCNTROL ANALYSIS	H.A.	INCREASES	MULTIPLE	N.A.	N.A.	INCREASES	INCREASES
o PLAINTHG	DECREASES	N.A.	N.A.	N.A.	INCREASES	INCREASES	N.A.
o FLIGHT CONTROL	DECREASES	INCREASES	MULTIPLE	N.A.	N.A.	N.A.	N.A.
O AMPLYSIS ANOMALIES	DECREASES	INCREASES	MULTIPLE	N.A.	M.A.	N.A.	N.A.
o CHECKOUT	DECREASES	N.A.	MULTIPLE	N.A.	п.А.	N.A.	N.A.
o ACTIVATION	DECREASES	N.A.	MULTIPLE	N.A.	и.А.	N.A.	N.A.
FLIGHT EVALUATION (320-11/12-03)					,		
o DATA REDUCTION	H.A.	INCREASES	MULTIPLE	N.A.	й. А.	N.A.	A.A.
o DATA ANALYSIS	li.A.	THOREASES	MULTIPLE	N.A.	H.A.	H-H	त । स
O FESOLVE ANOMALIES	H.A.	INCREASES	MULTIPLE	H . A	M. A.	ж.д.	и. д.
o naogra	N.A.	INCREASES	andinos:	N.A.	И.А.	и. А.	N.A.
FLIGHT SUPPORT SOFTWARE (320-11/12-04	_		•		;		4
o Planining	H.A.	и. А.	N.A.	N.A.	<b>d</b>	INCREASES	H.A.
o flicit control	DECREASES	N.A.	₩. A.	N.A.	n :	INCREASES	INCREMENT
o SINUL/TICAS	DECFERSES	LACREMENTS.	d: :	4.	H . P.	VENERATION :	LINCREPACIO
o FLIGHT SUPPORT	1. A.	к. А.	N. A.	М. А.	A	is.A.	A . 4.
o CONTROL SUPPORT	INCREASES	N.A.	N.A.	N.A.	М.А.	INCREASES	LACKERSES
o FLIGHT EVALUATION	и.А.	и. А.	х.А.	N.A.	II.A.	z. A.	N.A.

The Operations tasks were further analyzed in terms of actual people and skills required. It was determined that a minimum operations crew (one for each of three shifts) was required for flight control of only one Tug flight. These crews are capable of handling a significant number of flights per month; a greater number than sometimes required by the mission model. Even though these crews are utilized to perform the mission planning, flight evaluation and flight support software tasks in addition to their flight control requirements, there is sometimes an excess of manhours available. In order to allow for this, the manhours available from the minimum crews are incorporated into the computer program as minimum for the 32C area. When the actual manhours requirements are calculated, if the total does not exceed the minimum, then the minimum is used and the unused manhours are shown. This minimum crew is required for both NASA and DOD.

Option 3 is a phased program consisting of two distant configurations. The initial configuration is operational for four years before the final configuration is introduced and overlaps the final configuration operational period by 4 years for NASA Tugs and 3 years for DOD Tugs. The final configuration has a seven year operational life. The initial configuration has a level IV autonomy, a 3 day mission duration and no rendezvous, docking or spin-up capability. The final configuration has a level III autonomy, a 6 day mission duration and has rendezvous, docking and spin-up capabilities. The appropriate factors including proportional values for the years during the overlap of the two configurations, the number of flights and the mission times were input into the computer program. The results of the calculations are shown in Section 4.

A variation of Option 3 which was examined was a 2 year delay in the operational date thereby shortening the program duration from 11 to 9 years. The numbers of flights per year and mission times were affected. The appropriate changes were made to these quantities in the computer inputs and the results of this run are shown in the following pages.

OPTION	3 - LATE TOC
YGAR	= 1980
NUMBER OF FLIGHTS	<b>= 12.</b> 0
AUTONOMY LEVEL	= 4.0
WASA_MISSION	
MISSION DURATION	= 40,5
LAUNCH FROM WIR	= C.O
LAUNCH FROM ETR	- <b>4-12.</b> n
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)
	MANHOURS COMPUTER HOURS COSTS
HISSION PLANHING	24452,3 221,8 573980,6
FLIGHT CONTROL	79809,6 855,7 1924308,2
FLIGHT EVALUATION	<b>20538,1</b> 270,2 514262,8
FLIGHT SOFTWARE	<del>= 12480,6                                    </del>
UNUSED MANHOURS	¥ 42755,9 0,0 855118,3
TOTAL OPS, HOURS	<b>=</b> 124800,0 1498,6
TOTAL OPS, COSTS	= 2808000,0 573946,2 3381946,2
OPERATIONS PER/FLT	COSTS = 281828,9

OPTION		<b>3</b> 84		
YEAR		4 1 5 3 7	<u> </u>	
NUMBER	OF FLIGHTS	a 20.9		
AUTONOM	Y LEVEL	· # - 4 <sub>10</sub>		
NASAH	ISSION			
MISSION	DURATION	<b>a</b> 38,4		
LAUNCH	FROM WTR	* 4.3		
LAUNCH	FROM ETR	H 16.7		
FLIGHT	OPERATIONS	RECURRING CO	STS (ANHUAL)	
		SPUCHMAN	COMPUTER HOURS	COSTS
HISSION	PLANNING_	30377,1	283,4	-716085 <sub>7</sub> 8
FLIGHT	CONTROL	60719,2	1385,1	1746044,7
FLIGHT	EVALUATION	= 33703,7	443,5	843922.1
	SOFTHARE	12485,0	235,0	40200 <b>5_B</b>
FLIGHT_			õ, o	6138,4
UNUSED	MANHOURS	m 306,9	•	<b>U</b>
	MANHOURS OPS. HOURS	# 1248 <u>0</u> 0.5	2350.0	

OFTION			3			
YEAR.		<u> </u>	954		<u>'</u>	
NUMBER	OF FLIGHTS	S = 2	<b>6.</b> 9			
AUTONO	MY LEVEL	=	3.0	•		
NASA_	MISSION					<del></del>
HISSIO	N DURATION	# 3	59,0			•
LAUNCH	FROM WTR	<b>E</b>	4,0		<del>,</del>	
_LAUNCH	FROM ETR	= 7	22.0		<del></del>	
FLIGHT	OPERATIONS	REC	JURRING (	COSTS CANNUAL	.)	
	<del></del>	4/	NHOURS	COMPUTER	HOURS	COSTS
_HISSIO	N PLANNING		42554	37	3,2	994067.0
FLIGHT	CONTROL	À	79321.	5 151	4,8	2166618,0
FLIGHT	EVALUATION	#	44021,	57	9.1	1102221.0
FLIGHT	SOFTWARE		16585	7 27	4,1	_519732,2
UNUSED	MANHOURS	#	٥,	5	0.0	0.0
TOTAL	ops, Hours	<b>4</b>	165897	5 274	1,2	
TOTAL	ops. costs	=	3732693	7 104988	4.4	4782578.1

OPTION	<b>3</b>
YEAR	= 198=
NUMBER OF FLIGHTS	<b>= 28,</b> 0
AUTONOMY LEVEL	× 3,5
NOTESTA ASAN	
MISSION DURATION	<b>39.</b> 5
LAUNCH FROM HTR	= 6,0
LAUNCH FROM ETR	* 22.)
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)
	MANADURS COMPUTER HOURS COSTS
MISSION PLANNING	<del>= 44459,1 392,7 1</del> 043585,0-
FLIGHT CONTROL	<b>a</b> 84754,9 1612.0 2312485,4
FLIGHT EVALUATION	<b>47031,7</b> 623,6 1179484,1
FLIGHT SOFTHARE	R 17644.6 292.1 552963,2
UNUSED MANHOURS	<b>a</b> 0,0 0.0
TOTAL OPS, HOURS	= 176443,8 292à,3
	# 3976 h29,4 1118488,3 5088517,7

OPTION	<b>.</b> 3	
YEAR	1986	
NUMBER OF FLIGHTS	= 24.)	
AUTONOMY LEVEL	ų 3,0	
NASA MISSION		
HISSION DURATION	m 36,7	
LAUNCH FROM HTR	<b>z</b> 4,0	
LAUNCH FROM ETR	* 23.3	
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)	)
	MANADURS COMPUTER I	HOURS COSTS
MISSION_PLANNING	= 39385,7 345	,1931.056,6
FLIGHT CONTROL	m 71649,3 137 <sub>3</sub>	,5 1957929,7
FLIGHT EVALUATION	<b>42161,7</b> 525	.4 1044475,6
FLIGHT SOFTWARE	= 15369,8 249	, 3 479745, 1
UNUSED MANHOURS	å 0,6 d	,0 0,0
TOTAL OPS, HOURS	= 133697,7 2493	, 3
TOTAL OPS COSTS	= 3458108.c 955309	<del>, 2 4413206-9</del>

YEAR			•
NUMBER OF FLIGHTS	<b>= 24,</b> 0		
AUTONOMY LEVEL	<b>3</b> ,0		
NASA MISSION		<u> </u>	
MISSION DURATION	= 45,8	•	•
LAUNCH FROM WTR	<b>#</b> 6.0		
LAUNCH FROM ETR	<b>8 18.</b> 0		
FLIGHT OPERATIONS	RECURRING CO	ETS (ANNUAL)	
	AVNHUNS	COMPUTER HOURS	COSTS
MISSION PLANNING	# 41182,I	357,3	96 <sub>6</sub> 561 <sub>4</sub> 5
FLIGHT CONTROL	75565.2	1492,6	2091784,8
FLIGHT EVALUATION	# 45052.2	561,5	1116080,5
FLIGHT SOFTWARE	16224,6	267,3	5¢622 <b>5_3</b>
UPUSED MANHOURS	0.0	0,0	0,0
TOTAL OPS, HOURS	= 1622 <b>40</b> +5	2679,5	
	R 3688411.1	4 - 5 - 6 - 4	4676552,1

OPTION	я 3		
YEAR	= 1988		
NUMBER OF FLIGHTS	= 19.0		
AUTONOMY LEVEL	<b>=</b> 3.9		
NASA MISSION AZAN			
MISSION DURATION	<b>=</b> 48,6		•
LAUNCH FROM WTR	<b>=</b> 4,0		
LAUNCH EROM ETR	a 15, 3		,
FLIGHT OPERATIONS	RECURRING CO	STS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
HISSION PLANNING	± 37798,7	325,7	882821,1
FLIGHT CONTROL	= 59849,7	1147,9	1636653,0
FLIGHT EVALUATION	= 42917,5	453,3	1031947,8
FLIGHT_SOFTWARE	<u>= 14676,6</u>	213,5	4337.04_0
UNUSED MANHOURS	, ö	5 , 0	0,0
TOTAL OPS, HOURS	= 1407 <u>6</u> 5,8	2135,5	<u> </u>
		817895,1	

OFTION	***	**************************************	÷
YEAR	# 19k9		
NUMBER OF FLIGHTS	= 25,¢		
AUTOHOMY LEVEL	z 3,0		
NASA_MISSION			
HISSION DURATION	<b>=</b> 35,4		
LAUNCH FROM HTR	= 5.0		
LAUNCH FROM ETR	= 20.3		
FLIGHT OPERATIONS	RECURRING COS	TS (ANNUAL)	. •
	MANHOUPS	COMPUTER HOUPS	COSTS
MISSION PLANNING	R 41678,5	354,8	957440,5
FLIGHT CONTROL	# 70412,7	1328,2	1916958,8
FLIGHT EVALUATION	= 42298,4	542.0	1093541,5
FLIGHT SOFTWARE	<u> </u>	247,2	479152,1
UNUSED MANHOURS	<b>*</b> 5,8	0,0	0,6
TOTAL OPS. HOURS	= 153789.2	2472,2	
	= 3460256.6	946841.9	4407097.9

OPTION	<b>=</b> 3	
YEAR	= 199 <del>0</del>	
NUMBER OF FLIGHTS	= 22,c	
AUTONOMY LEVEL	<b>3,</b> 0	
NASA_MISSION		
MISSION DURATION	= 37.5	<del>-</del>
LAUNCH FROM HTR	<b>= 4.0</b>	
LAUNCH ERON ETR	s_18,0	
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)	•
	MANHOURS COMPUTER HOURS	COSTS
HISSION PLANNING	<b>a</b> 41463.2 340.1	963101.3
FLIGHT CONTROL	± 59844,5 1065,7	1603115,0
FLIGHT EVALUATION	x 41299,6 484,6	1011563,5
FLIGHT SOFTWARE	<u> 1,4263,4 215,4</u>	437150_9
UNUSED MANHOURS	e 0.0	0,0
TOTAL OPS. HOURS	= 142531,2 2103,7	<u> </u>
TOTAL OPS. COSTS	= 3269262,4 805728,3	4014936,7

	The second secon								
	01710H			- LATE I	OC				1
	TOTAL PE	rogran	S.TS		· · · · · · · · · · · · · · · · · · ·				
-	NUMBER (	P FILIGHT	S = 200.0	)					•
	AUTONOMY	LEVEL	z 3,:			Harata da enne - wee see	er van van de een een een een een een een een een		
	NASA_MI	SSION	ulingdo our por ens contangua	<del></del>	<del></del>				<del></del>
	LAUNCH I	FROIL HTR	a 37.0	)					
	LAUNCH I	ROH ETE	<b>= 163.</b> 0	)	· · · · · · · · · · · · · · · · · · ·		april e a la las grans des establishes de de de la las establis de la las establishes establishes establishes		
	_FLIGHT	DEERATIONS	RECURI	21:1G	IAN) LETE	SAONLY	·)		
			МУНН	URS	COMPUTER	HOURS	COSTS	•	
	MISSION	PLANNING	= 31	43676.7	30	000.3	8022639.3		
	_FLIGHT	CONTROL	61	42367.2	117	771.7	17355897.7_		
	FLIGHT	EVALUATION	1 m 3	59023.9	<u>1</u> ,1	483.0	8897498.8		
	FLIGHT	SOF TWARE	g 1	34506.8	2:	139.4	4182078.3	<del></del>	
	_UNUSED!	MANHOURS		43063.1 _		0.0	861256.8_		<del></del>
	TOTAL O	s, Hours	; <u> </u>	45067.7	21:	394.5		•	
	TOTAL DI	PS. COSTS	3020	64022.2	81940	091.9	38458114.1		
	. OPERATIO	NS PERZELT		_= 1922	290.6 _				
<del></del>	FLIGHT	PERATIONS	NUN-RI	ECURRING	COSTS (	TOTAL P	Rogran <b>for B</b> o	TH DOD	thasa)
			MAN	HOURS	COMPUTE	н нопа	s costs		
	- MISSION	PLANHING	} <b>8</b>	47 <del>826476</del>	5	00470	11543527.2	. ·	
	FLIGHT	CONTROL		52263.9		0,0	1175938.2	,	
	FLIGHT	EVALUATION	ON =	J, 0		0,0	0.0	<del></del>	
	FLIGHT_	_SOF_TWARE		178005.2	3:	122.3 -	<del></del> 5200963.6		
	TOTAL	DDT E Hol	URS =	709133.7	5	130.3	٠.		
• . ···	. TOTAL	DUT E CO	STS = 15	955509.0	1964	904.9	17920429.0		
·		·		:					

OPTION	5 - LATE TOC	
YEAR	= 1982	
NUMBER OF FLIGHTS	<b>10.</b> 0	
AUTONOMY LEVEL	m 4,0	<del>· · · · · · · · · · · · · · · · · · · </del>
DOD _MISSION		·
MISSION DURATION	<b>* 39,8</b>	
LAUNCH FROM WTR	# C.O	
LAUNCH FROM ETR	E 10.0	
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)	•
	MAILHOURS COMPUTER HOURS	COSTS
MISSION PLANHING	E 22395,5 205,6	536639,
FLIGHT CONTROL	= 84877,2 707,3	1968440,8
FLIGHT EVALUATION	17027,3 224,0	426355,2
FLIGHT SOFTWARE	12480.0 125.3	36:381,7
UNUSED MANHOURS	# 54223,1 0,0	1084462,0
TOTAL OPS, HOURS	<b>= 1248.00,0 1263,2</b>	
TOTAL OPS. COSTS	<b>≡ 28</b> 0800 <b>0.</b> δ 463817.4	3291817.4

OFTION	•	3		•	
_YEAR		1983			
NUMBER OF	FLIGHTS :	16,9 17			
AUTONOMY	LEVEL	4.0			
DOD HISSI	011				
MISSION D	URATION	42,9		•	
LAUNCH FR	IOH HTR	4.0			
LAUNCH FR	ON ETR	12.5			
FLIGHT OF	PERATIONS F	RECURRING	COSTS	(ANNUAL)	
		MANHOURS	ÇO	MPUTER HOL	IRS COSTS
MISSION_P	LANNING	27571	,5	255,3	651192,6
FLIGHT CO	NTROL	69263	, ď	1178,6	1836647,4
FLIGHT EV	ALUATION :	27265	,5	366,7	697736,3
_FLIGHT_SO	FTWARE	12480	٠ <u>۵</u>	200,1	388619-6
UNUSED MA	NHOURS	18629	.5	8.0	372590,5
TOTAL OPS	. HOURS	124840	0,0	2000,5	
	cosTS	2803000			3574195-0

OFTION	<b>=</b> 3			
YEAR	<u></u>			
number OF FLIGHTS	<b>= 1</b> 3,0			
AUTONOMY LEVEL	<b>= 4.</b> 9			
DOD MISSION				
MISSION DURATION	<b>= 4</b> 0.6			
LAUNCH FROM HTR	<b>= 1.</b> 0			
LAUNCH FROM ETR	= 17.7		<del></del>	
FLIGHT OPERATIONS	RECURRIN	G COSTS	(ANNUAL)	
and the second s	SUCHIAN	s co	HPUTER HOURS	COSTS
HISSION PLANNING	<u> </u>	34,3	285,5	721027.9
FLIGHT CONTROL	<b>a</b> 633	85,5	1297,1	1765279,2
FLIGHT EVALUATION	= 308	27,7	405,7	771959,1
FLIGHT SOFTWARE	1.24	80,0	221,1	396596_3
UNUSED MANHOURS	a 4 4	53,2	5.0	89064,6
TOTAL OPS. HOURS	= 1,248	00,0	2211,4	
TOTAL DESIGNOSTS	= 28 <sub>0</sub> 80	00.0	846962.5	_3,634,962,5
OPERATIONS PER/FLT	COSTS =	20305	3,5	

. OPTION	* 3		
YEAR	# 198s	·	
NUMBER OF FLIGHTS	<b>4 13,</b> 0		
AUTONOMY LEVEL	<b>* 3</b> ,0		
DOD MISSION			
MISSION DURATION	= 48,5		•
LAUNCH FROM WTR	m 2,0 ·		, t
LAUNCH FROM ETR	B 11.0		<del></del>
FLIGHT OPERATIONS	RECURRING COSTS (	ANNUAL)	
	MANHOURS COMP	UTER HOURS	COSTS
MISSION PLANNING	a 3214B, a	261.4	743089.6
FLIGHT CONTROL	40122.1	765,9	1095789,3
FLIGHT EVALUATION	4 39255,4	309,9	903803,5
FLIGHT SOFTWARE	4 11152,6	148,6	335721,9
UNUSED MANHOURS	9.5	6.0	0.0
TOTAL CPS, HOURS	* 111526,3	1485,8	
TOTAL OPS. COSTS	# 2309342,6	569061,0	3078403,6
OPERATIONS PER/FLT	10070 = 074000 °	*	

OPTION	<b>3</b>		
YEAR	= 1986		<del></del>
NUMBER OF FLIGHTS	= 17.0		•
ALITONOMY LEVEL	<b>= 3,</b> 0		
DUD HISSION			
HISSION DURATION	= 36,4		
LAUNCH FROM WTR	= 5,0		
LAUNCH FROM ETR	<del>= 12,3</del>		
FLIGHT OPERATIONS	RECURRING COS	TS (ANNUAL)	,
	SSUDEPAR	COMPUTER HOURS	COSTS
HISSION PLANHING	<del>1 36365, j</del>	302,3	<del>843084,7</del>
FLIGHT CONTROL	48192,2	853,2	1276635,8
FLIGHT EVALUATION	<b>38189,9</b>	371,3	936020.7
FLIGHT SOFTWARE	= 12774,9	169,6	371845,7
UNUSED MANHOURS	# D,6	<b>5</b> • 0	0.0
TOTAL AND HANDS	= 122743.1	1696,5	<del></del>
TOTAL OPS, HOURS			

•			
OFTION	<b>=</b> 3		•
YEAR	# 1957		
NUMBER OF FLIGHT	'S = 15,0		
AUTONOMY LEVEL	# 3.0	,	,
DOD MISSION		`	
MISSION DURATION	<b>= 47.3</b>	-	
LAUNCH FROM WTR	= 2.0		
LAUNCH FROM ETR	= 14.0		
FLIGHT OPERATION	S RECURRING COST	S (ANNUAL)	
*	MANADURS C	OMPUTER HOURS	COSTS
MISSIONPLANNING	75489.5	293,3	822114,8_
FLIGHT CONTROL	48948,9	925,0	1331341,3
FLIGHT EVALUATION	N # 40733,4	379,3	959546,2
FLIGHT SOFTHARE	12517,2	175,8	336659.1_
UNUSED MANHOURS	2,6	ä.O	0.0
TOTAL OPS. HOUR	S = 125172, j	1765,4	
TOTAL OPS . COS	<u>S = 2816369,5</u>	677291,9	_3423661-,4
OPERATIONS PER/FI	T COSTS # 2183	353.8	

OPTI	N	. =	3			
- YEAR-	مستند فالمتراوات والمتراوات		1099			
NUMAI	R OF FLIGH	TS = :	18.0			
·	MISSION LEVEL	#	3,0		4	
HISS	ION DURATION	<b>*</b> (	39.1	£		
LAUN	H FROM WTR	3	2.0		•	
LAUN	H FROM 67R	<u> </u>	14,0			
FLIG	T OPERATION	IS RE	CURRING	COSTS	(ANNUAL)	
	· <del></del>	Υ.	ANHOURS	COM	PUTER HOURS	COSTS
MISS	ION—BLANNING		<del>380</del> 62,	3	314,6	881738,6-
FLIG	HT CONTROL	=	50331,	1	888,9	1347077,3
FLIG	T EVALUATIO	N B	39533,	5	401,2	944330,0
FLIG	IT SOFTHARE	<u></u>	12792,	7	179,3	338107_3
UNUS	ED MANHOURS	幕	ō,	ė į	5.0	0.0
TOTA	. ops, Hour	IS #	127926,	A	1783,0	
			2878353.		682897.7	3561252,9

. 0	PTION			3		•
Y	EAR		<del></del>	1930		
N	UMBER	OF FLIGH	rs =	16,5		·
•	UTONOMY	LEVEL	4	3,0		
М	ISSION	DURATION		51.2		
L	AUNCH	FROM WTR	8	4,0		
L	AUNCH	FROM ETR		12,0		
F	LIGHT	OPERATION	S RS	CURRING C	OSTS (ANNUAL)	
			. ,	SFUCHMAN	COMPUTER HOUR	s costs
M	ISSION	PLANNING	8_	36229,4	295,9	837904,5
F	LIGHT	CONTROL	Ţ	43483,7	910,3	1318312,8
F	LIGHT	EVALUATIO	N s	41841.5	388,6	935653.8
<b>.</b> F	LIGHT_	SOFTHARE	<u>#</u> .	13653,4	177,2	384250 <del>,7</del>
ι	JNUSED	MANHOURS	ą.	5.8	ğ.0	0.0
1	TOTAL	ops, Hour	S =	126554.2	1771,9	
			_	2847468		3526121 <del>, 9</del>

OPTION	ngin <b>3</b> Manggaran sa kab	•	
YEAR	<del>- 1999</del>		
NUMBER OF FLIGHTS	<b>= 18.</b> 9		
AUTONOMY LEVEL	я 3.9		
DOD MISSION			
MISSION DURATION	* 40.72	i de Sala	
LAUNCH FROM WTR	<b>1.</b> 0		
LAUNCH FROM GTR	= 17,3		
FLIGHT OPERATIONS	RECURRING COS	TS (ANNUAL)	
	MAN HOURS	COMPUTER HOURS	COSTS
MISSION_PLANNING	± 38632,4	314,3	8\$1153 <sub>1</sub> 6
FLIGHT CONTROL	50802,3	906.4	1363214,6
FLIGHT EVALUATION	# 40001.6	405,0	955510,6
FLIGHT SOFTWARE	12384,3	189.7	321331_9
UNUSED MANHOURS	π 5,δ	0,0	0,0
TOTAL OPS. HOURS	4 125843.4	1807,4	
TOTAL DPS. COSTS	# 2808077,2	692233,5	3524210.7_
OPERATIONS PER/FLT	ngts = .00	511.7	

				•
OPTION	= 3 - LATE I	oc		
TOTAL PROGRAHCOS	T\$			er armediske innskard i st. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.
NUMBER OF FLIGHTS	<b>±</b> 142.0			٠
AUTONOMY LEVEL	= 3.0		en e	
_DODMISSION				· · · · · · · · · · · · · · · · · · ·
LAUNCH FROM HTR	= 21,0			
LAUNCH FROM ETR	<b>=</b> 121.0			
_FLIGHTOPERATIONS_	RECURRING CO	SIS (DOD ONLY	)	
	MANHOURS	COMPUTER HOURS	COSTS	
MISSION PLANNING	<b>=</b> 297486.2	2528.0	6917945.4	
FLIGHT CONTROL	504406.4	8429.8	13316738.5	
FLIGHT EVALUATION	<b>a</b> 315278.2	3251.6	7550915.4	
FLIGHT SOFTWARE	* 111717.1	1578.8	3397614.0	
_UNUSEDMANHOURS	_= 77305 <b>.</b> 9 _	0.0	1546117.1	
TOTAL OPS. HOURS	<b>*</b> 1117170.8	15788.2		
TOTAL OPS, COSTS	m 25136344.0	6046869.4	31183213.3	. The state of the
_OPERATIONS_PER/FLT_	gusts 21	9600.1		
FLIGHT OPERATIONS	NON-REGURRING	COSTS (TOTAL PR	ngrail for Both I	DOD FNASA)
	MANHOURS	COMPUTER HOURS	COSTS	
MISSIONPLANNING	4782 <del>64 6</del>	2008-0	11543527,2	
FLIGHT EVALUATION	<del></del>		0,0	
FLIGHT SOFTWARE	· · · · · · · · · · · · · · · · · · ·		5200963.6	
TOTAL DOT E HOURS		5130.3		
	NUMBER OF FLIGHTS AUTONOMY LEVEL DOD MISSION LAUNCH FROM MTR LAUNCH FROM ETR FLIGHT OPERATIONS MISSION PLANNING FLIGHT CONTROL FLIGHT SOFTWARE UNUSED MANHOURS TOTAL OPS, COSTS OPERATIONS PER/FLT FLIGHT OPERATIONS  TOTAL OPS, COSTS OPERATIONS PER/FLT FLIGHT OPERATIONS  MISSION—PLANNING— FLIGHT CONTROL FLIGHT CONTROL FLIGHT CONTROL FLIGHT SOFTWARE	TOTAL PROGRAM COSTS  NUMBER OF FLIGHTS = 142.0  AUTONOMY LEVEL = 3.0  DOD MISSION  LAUNCH FROM HTR = 21.0  LAUNCH FROM ETR = 121.0  FLIGHT OPERATIONS RECURRING COMMANHOURS  MISSION PLANNING = 297486.2  FLIGHT CONTROL = 504406.4  FLIGHT EVALUATION = 315278.2  FLIGHT SOFTWARE = 111717.1  UNUSED MANHOURS = 77305.9  TOTAL OPS, HOURS = 1117170.8  TOTAL OPS, COSTS = 25136344.0  OPERATIONS PER/FLT COSTS = 21  FLIGHT OPERATIONS NON-RECURRING MANHOURS  MISSION—PLANNING = 478264.6  FLIGHT CONTROL = 52263.9  FLIGHT EVALUATION = 0.0  FLIGHT SOFTWARE = 178005.2	NUMBER OF FLIGHTS = 142.0  AUTONOMY LEVEL = 3.0  DOD MISSION  LAUNCH FROM HTR = 21.0  LAUNCH FROM HTR = 121.0  FLIGHT OPERATIONS RECURRING COSTS (DOD ONLY MANHOURS COMPUTER HOURS MANHOURS COMPUTER HOURS MANHOURS CONTROL = 504466.4 8429.8  FLIGHT CONTROL = 315278.2 3251.6  FLIGHT SOFTWARE = 111717.1 1578.8  UNUSED MANHOURS = 111717.1 1578.8  UNUSED MANHOURS = 1117170.8 15788.2  TOTAL OPS, HOURS = 1117170.8 15788.2  TOTAL OPS, COSTS = 25136344.0 6046869.4  OPERATIONS PER/FLT CUSTS = 219600.1  FLIGHT OPERATIONS NUN-RECURRING COSTS (TOTAL PROPERTIONS NUN-RECURRI	NUMBER OF FLIGHTS = 1½2.0  AUTONOMY LEVEL = 3.0  DOD MISSION  LAUNCH FROIL HTE = 21.0  LAUNCH FROIL ETR = 121.0  FLIGHT OPERATIONS RECURRING COSTS (DOD ONLY)  MANHOURS COMPUTER HOURS COSTS  MISSION PLANNING = 297½86.2 2528.0 69179½5.½  FLIGHT CONTROL = 50½406.½ 8½29.8 13316738.5  FLIGHT EVALUATION = 315278.2 3251.6 7550915.½  FLIGHT SOFTWARE = 111717.1 1578.8 339761½.0  UNUSED MANHOURS = 77305.9 0.0 15½6117.1  TOTAL OPS, HOURS = 1117170.8 15788.2  TOTAL OPS, COSTS = 251363¼4.0 60¼6869.½ 31183213.3  OPERATIONS PER/FLT CUSTS = 219600.1  FLIGHT OPERATIONS NUN-RECURRING COSTS (TOTAL PROGRAM FOR BOTH)  MANHOURS COMPUTER HOURS COSTS  MISSION—PLANNING = 478244.6 200870 11543527;2  FLIGHT CONTROL = 52263.9 0.0 1175938.2  FLIGHT EVALUATION = 0.0 0.0 0.0  FLIGHT SOFTWARE = 178005.2 3122.3 5200963.6

The Work Breakdown Structure for the Tug Study divides the flight operations into four areas or blocks, namely: Mission Planning, Flight Control, Flight Evaluation, and Flight Support Software. In order to develop a means of assessing the relative complexity of flight operations for various Tug configurations, it was first necessary to adequately define flight operations. This was accomplished by analyzing the four WBS blocks to determine the specific tasks required in each. These tasks fell into three categories: one time efforts completed prior to the first operational flight, a continuing level of effort for the operational life of the program, and those efforts performed once for each flight. The one time efforts were considered to be part of the DDT&E activities (32A) while the continuing and per flight efforts were assigned to the Operations activities (32C). With this format developed, a reference configuration was chosen (Number 101) and an estimate was made of the manhours and computer time required to accomplish each flight operations task considering the specific characteristics of that configuration.

With the reference configuration estimates determined as a point of departure, it was necessary to establish criteria or a rationale for assessing the operational workload differences between configurations. An analysis of this area concluded that the workload was proportional to the operational complexity of the configuration and the mission. It was also decided that the configuration complexity could primarily be measured by autonomy level and the mission complexity by mission duration. Since the reference configuration was autonomy Level IV (completely dependent on ground support/simple onboard equipment), Level IV was given a reference value of 1.0 and the other levels given relative values to reflect the degree of difference. When autonomy level was used to measure workload related to ground support dependence, the workload decreased with increasing autonomy levels and values were assigned as shown below. It was assumed that ground support effort would not be charged to highly autonomous configurations not requiring that support even though experience indicates that it may be required for some other reason. Some task workloads are proportional to the complexity of onboard equipment and therefore increase with increasing autonomy levels. (Level II was considered the highest level because of the additional mission planning capability.) Values were also assigned as shown below:

AUTONOMY LEVEL	EQUIPMENT COMPLEXITY VALUE	DEPENDENCE ON GROUND SUPPORT VALUE
IV .	1.0	1.00
III	1.5	.67
I	2.0	.50
II	2.5	.40

Since the reference configuration was a minimum (1 day) mission configuration, a reference value of 1.0 was given to the 1 day duration and the other durations were assigned relative values as follows:

## MISSION DURATION

DAYS	VALUE
1	1.0
1.5	1.1
3	1.4
6	2.0

Assignment of these values take into account the fact that a configuration capable of longer duration missions does not fly all long duration missions and the average mission length is actually shorter. To obtain a more precise assessment of the effect of mission duration, actual mission time in hours for each flight can be used in lieu of the single mission duration factor value above.

Some tasks must be performed for each flight and, therefore, the reference configuration estimate (per flight) must be multiplied by the number of flights.

For those configurations where phasing occurs from an initial to a final configuration, the continuing level of effort tasks were factored for the number of years the configuration is to be operational. Since the total operational program is eleven years and the configurations are operational for either four, seven, or eleven years, the following values were assigned:

## PROGRAM DURATION

OPERATIONAL YEARS	•	VALUE
11		1.0
7		0.7
14		0.4

While the program duration factor proportions the effort between two phased configurations, it does not take into consideration that many of the efforts completed for the initial configuration must be repeated for the final configuration. To take this into account a factor was established as follows:

## DEVELOPMENT PROGRAM

DIRECT DEVELOPMENT VALUE

PHASED PROGRAM VALUE

1.0

1.7

Since the reference configuration did not have retrieval capability additional complexity is introduced by those configurations having rendezvous, docking and payload spin up capability. Appropriate values were assigned to these factors:

RENDEZVOUS A	IND DOCKING	PAYLOAD SPIN-UP C	APABILITY
NOT REQUIRED	REQUIRED	NOT REQUIRED	REQUIRED
1.0	1.2	1.0	1.04

With all the complexity factors defined, an assessment was made for each task to determine which factors affected the effort required relative to the reference configuration and how they varied. A summary matrix of the tasks and factors is shown on a following page.

Using the manhours and computer hours estimated for the reference configuration and applying the appropriate factors to each operations task, equations were prepared which could be computed and summed to provide the total flight operations effort for any Tug program or configuration. A computer program incorporating these equations was developed to provide maximum flexibility in determining flight operations efforts for various programs and trade studies. Separate manhours, computer hours and dollar costs are computed for each WBS element (Mission Planning, Flight Control, Flight Evaluation and Flight Support Software) in the DDT&E (WBS 32A) and the Operations (WBS 32C) areas. The Operations estimates are computed for each year of the operational program and totaled. The NASA and DOD figures are computed separately.

## SENSITIVITIES FOR FLIGHT OPERATIONS FUNCTIONS

WBS 320-11/12

RENDEZVOUS SPIN-UP	INCREASES INCREASES INCREASES INCREASES INCREASES INCREASES INCREASES	INCREASES	INCREASES INCREASES INCREASES INCREASES INCREASES IN.A. IN.A	N.A. N.A. N.A. N.A. N.A. N.A. N.A. N.A.	INCREASES INCREASES INCREASES INCREASES N.A. INCREASES INCREASES N.A. INCREASES N.A. INCREASES
PROGRAM PHASING	N.A. INCREASES INCREASES	INCREASES INCREASES INCREASES INCREASES INCREASES INCREASES INCREASES INCREASES	N.A. INCREASES N.A. N.A. N.A.	N.A. N.A. N.A.	M M M M M M M M M M M M M M M M M M M
PROGRAM	N.A. MULTIPLE N.A.	MULTIPLE MULTIPLE MULTIPLE N.A. N.A. MULTIPLE MULTIPLE	N N N N N N N N N N N N N N N N N N N	N N N . A . N . A	жж. ж. ж. ж. ж.
NUMBER OF FLIGHTS	MULTIPLE N.A. MULTIPLE	N N N N N N N N N N N N N N N N N N N	MULTIPLE MULTIPLE N.A. MULTIPLE MULTIPLE MULTIPLE MULTIPLE	MULTIPLE MULTIPLE MULTIPLE MULTIPLE	м. А. м. А. м. А.
MISSION	INCREASES N.A. N.A.	N N N N N N N N N N N N N N N N N N N	INCREASES INCREASES N.A. INCREASES INCREASES N.A.	INCREASES INCREASES INCREASES INCREASES	N.A. N.A. INCREASES N.A. N.A.
AUTONOMY	N.A. INCREASES INCREASES	N.A. DECREASES INCREASES N.A. INCREASES INCREASES INCREASES	DECREASES N.A. DECREASES DECREASES DECREASES DECREASES DECREASES	N N N N N N N N N N N N N N N N N N N	N.A. DECREASES DECREASES N.A. INCREASES N.A.
WBS LEVELS	(320-11/12-01) NALYSIS S	o MISSION RULES o COMMAND HANDBOOK o PROCEDURES AND CHECKLISTS o INSTRUMENTATION LIST o OPERATIONAL DATA BOOK o SYSTEM SCHEMATICS o INTERFACE DRAWINGS o SCHEDULES	FLIGHT CONTROL (320-11/12/02)  o CONTROL REQUIREMENTS o CONTROL ANALYSIS o FLIGHT CONTROL o ANALYSIS ANOMALIES o CHECKOUT o ACTIVATION	FLIGHT EVALUATION (320-11/12-03) o DATA REDUCTION o DATA ANALYSIS o RESOLVE ANOMALIES o REPORT	FLIGHT SUPPORT SOFTWARE (320-11/12-04 o PLANNING o FLIGHT CONTROL o SIMULATIONS o FLIGHT SUPPORT o CONTROL SUPPORT o FLIGHT EVALUATION

4-55

The Operations tasks were further analyzed in terms of actual people and skills required. It was determined that a minimum operations crew (one for each of three shifts) was required for flight control of only one Tug flight. These crews are capable of handling a significant number of flights per month; a greater number than sometimes required by the mission model. Even though these crews are utilized to perform the mission planning, flight evaluation and flight support software tasks in addition to their flight control requirements, there is sometimes an excess of manhours available. In order to allow for this, the manhours available from the minimum crews are incorporated into the computer program as minimum for the 32C area. When the actual manhours requirements are calculated, if the total does not exceed the minimum, then the minimum is used and the unused manhours are shown. This minimum crew is required for both NASA and DOD.

Option 3 is a phased program consisting of two distinct configurations. The initial configuration is operational for four years before the final configuration is introduced and overlaps the final configuration operational period by 4 years for NASA Tugs and 3 years for DOD Tugs. The final configuration has a seven year operational life. The initial configuration has a level IV autonomy, a 3 day mission duration and no rendezvous, docking or spin-up capability. The final configuration has a level III autonomy, a 6 day mission duration and has rendezvous, docking and spin-up capabilities. The appropriate factors including proportional values for the years during the overlap of the two configurations, the number of flights and the mission times were input into the computer program. The results of the calculations are shown in Section 4.

The effect of DOD procurement of the Tug program on Option 3 was analyzed. This permitted operational mission flights of the final configuration two years earlier and changed the numbers of flights per year and the mission times. The computer program inputs were revised to reflect these changes and the results are shown in the following pages.

:	OPTION	# 3 DOD BUY	
	YEAR	1980	· · · · · · · · · · · · · · · · · · ·
	NUMBER OF FLIGHTS	<b>3</b> ,6	
	AUTONOMY LEVEL	<b>3.0</b>	
	NASA HISSION		
	MISSION CURATION	= 43,0	
	LAUNCH FROM HTR	= 0,0	
- · .	-LAUNCH FOM ETR	± 3,0	
	FLIGHT OFERATIONS	RECURRING COSTS (ANNUAL)	
		MANHOURS COMPUTER HOURS	COSTS
	MISSION-FLANNING	: 17615,1 19t,6	40999014
	FLIGHT CONTROL	# 101956,3 221.3	2123870,4
·,	FLICHT EVALUATION	= 522£,5 68,8	130919,7
	-PLIGHT - SCFTHARE-	12486.0 45.0	330753,4
	UNUSED MATHOURS	# 92453.0 G.C	1849059,2
	TOTAL OPS, HOURS	= 12480C,0 489,6	
	TOTAL UPS COSTS	- 2acecoc, 0 127933,9	

YEAR		= 1981		. <i>y</i>			
	e erteuts					e e e e e e e e e e e e e e e e e e e	
MOMBER C	F FLIGHTS	= 1710					
AUTONOMY	LEVEL	<b>3</b> ,0					
MASA-MIS	SION						-
HISSION	CURATION	= 41,5	·				
LAUNCH E	RUM WTR	# 0,0	)				
LAUNCH	ACH ETR	* 14,1					
FLIGHT C	FERATIONS	RECURI	ING CO	STS (ANNUA	L)		
)		MANK	URS	COMPUTER	HOURS	CCSTS	
HISSION	FLANKING		26019,2	23	8,0	611466	7
FLICHT S	CNTROL		74718.4	100	7,4	1880210,	4
FLIGHT E	VALUATION	8	24066.4	31	6.7	602609.	7
	SCFTHARE	<del>- i</del>	12485,0		7,1	378476	3-
	:ANHOURS	<b>#</b>	31220,3		0.0	624406,	7
TOTAL DI	PS. HOURS	* 1	24800.0	173	5,7		
POTA1 (:	PS,COSTS-	28	cese <b>c.</b> 0	66476	3,1	-34727637	1

OPTION		Ħ	3		
YEAR		<del></del>	1982		
NUMBER	CF FLIGHTS	ä	8,0		
AUTONOM	Y LEVEL	Ħ	3,0		•
MASA N	ISSION			en e	
MISSION	CURATION		39,2		
LAUNCH	EROM WTR		0.0		
LAUNCH	PROM-ETR	<u> </u>	8.0		
FLIGHT	CPERATIONS	RE	CURFING COS	STS (ANNUAL)	
			ANHOURS	COMPUTER HOURS	costs
MISSION	FLANNING-		23971,6	197.7	555681,1
FLIGHT	CCHTROL	F	872 <b>66</b> ,7	472.8	1926409,2
FLIGHT	EVALUATION	*	13561.7	178.4	339577,6
-PLIGHT	-SEFTHARE-	ē-	12480,0	94.0	348118,7
UNUSED	MANHOURS	æ	65569.1	ŋ, C	1311381,9
TOTAL	DPS, HOURS	*	124800,0	943,0	
•	-ups,costs			361160.5	-31691867

SPTICH	7 3		
YEAR	-=-1983		
NUMBER OF FLIGHTS	# 15,0	• •	
AUTOHOMY LEVEL	# 3,0		
HASA-MISSION-			
HISSION EURATION	= 37,1		
LAUNCH EROM WTR	H 4,0		· · · · · · · · · · · · · · · · · · ·
LAUNCH-EFOH-ETR-	H 15,0		
FLICHT CPERATIONS	RECURFING C	OSTS (AMEUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
MISSION FLANKING	28046.2	249,1	656203,6
FLIGHT CONTROL	= 71726,5	946,9	1797176,1
FLIGHT EVALUATION	<b>=</b> 25033.3	329.4	626821,1
-FLIGHT-SCFTWARE	1248610	169.5	378911,2
UNUSED MARHOURS	= 2933E,4	0.0	586767,6
TOTAL OPS: HOURS	= 12480C.C	1694,5	
TOTALOPSCOSTS-	- 280800CT	649112,0	3457112,0
OPERATIONS PER/FLT	COSTS = 2	30474.1	

OPTION				, s
YEAR		L984		
NUMBER OF	rlights = 1	26,0		
AUTONOMY	LEVEL #	3,0		
NASA-HISS	to <del>N</del>	·		
HISSION C	URATION # 3	39,0		
LAUNCH FR	OH NTR #	4,0		
- LAUNCH L'AI	CH ETR	55.0	<u></u>	
FLIGHT OF	ERATIONS RE	CURFING COST	S (ANNUAL)	
	M	ANHEURS C	OMPUTER HOURS	ÇOSTS
HISSION-F	LANKING F	43066,7	375,4	1003913.2
FLIGHT CC	NTROL #	78226,1	1481,2	2131810,5
FLIGHT EV	ALUATION #	44021,6	579,1	1162221,0
- PLIGHT-se	FTWARE	16525,4	270,0	51678677
UNUSED MA	NHQURS #	· C , O	0.0	ŭ,0
TOTAL CPS	, FOURS =	165254,4	2736,3	
TOTAL-OHS	cost9	-3718224,6	1036506.6	<del>-47547327</del> 4

OPTION	# 3
YEAR	= 1985
NUMBER OF FLIGHTS	= 28,0
AUTONOMY LEVEL	4 3,0
NASA MISSION	
MISSION CURATION	# 39,0
LAUNCH EFRM WTR	# 6,0
LAUNCH PROM ETR	± 55'0
FLIGHT OFERATIONS	RECURRING COSTS (ANNUAL)
	MANHOURS COMPUTER HOURS COSTS
HISSION-FLANNING	47214,9 405,7 1099685,6
FLIGHT CONTROL	= 76279,7 1412.9 21C6729,0
FLIGHT EVALUATION	= 47031,7 623,6 1179484,1
-PLIGHT SCFTWARE	<del>= 17252,6 271,4 555246,1</del>
UNUSED MARHOURS	# C,0 G.D U,0
TOTAL OPS, HOURS	= 172526,3 2713,6
TOTAL COSTS-	= 3861842,2 1039302,0 4921144,8
OPERATIONS PERFELT	OSTS = 175755,2

CLOWA PION NCH	LEV SSION CURA FROM	ATION	SF	3,0 36,7 4,0	COSTS			
CLOWA PION NCH	SSION CURA FROM	VEL ATION WTR —ETR—	F	3,0 36,7 4,0 20,0	COSTS			
NCH SION	EURA FROM FROM-	ATION WTR —ETR—	8	36,7 4,0 20,0	COSTS			
SION NCH	FROM-	WTR ETR	#	4,0	COSTS			
VCH	FROM-	WTR ETR	#	4,0	COSTS			
VCH	EROM-	-ETR-	8-	20.0	COSTS			
					COSTS	A A A AMILA A	<del></del>	•
SHT	CFERA	TIONS	RI	ECURFING	COSTS			•
					20010	TANKUAL	)	
			P	MANHEURS	COI	MFUTER	HOURS	COST
ION-	FLAN	ı <del>k i Ng</del>		41104	<b>1 1 1 1</b>	353	<del>, 9</del>	957635
HŢ	ÇCHTR	CL	ş	£864g	,3			1862389
HT	EAVLA	MOITAL		42161	,7	525	, 4	1044475
iH7	<u> </u>	ARE-		<del></del>	76	239	,7	471585
ED	OHMAM	URS	*	. 6	.0			ن ن
<b>L</b> 0	PS.	HOURS		151906	,4	2397	, 4	· · · · · · · · · · · · · · · · · · ·
L0	H67-	COSTS-		<del>3417894</del>	74	<del>918191.</del>	<del> </del>	<del>-43</del> 36085-
GSAA	GHT-SED AL CI	GHT EVALL GHT SCFTH SED MANHO AL OPS. AL OPS.	GHT EVALUATION  GHT SCFTWARE  SED MANHOURS  AL OPS. HOURS  AL OPS. COSTS	GHT EVALUATION #  GHT SCFTMARE  SED MANHOURS #  AL OPS HOURS #  AL OPS COSTS	GHT EVALUATION # 42161  GHT SCFTMARE + 3519C  SED MANHOURS # C  AL OPS: HOURS # 151906  AL OPS: COSTS + 3417894	GHT EVALUATION # 42161.7  GHT SCFTWARE - 15190.6  SED MANHOURS # 0.0  AL OPS. HOURS # 151906.4  AL OPS. COSTS - 3417094.4	GHT EVALUATION # 42161.7 525  GHT SCFTWARE - 15190.6 239  SED MANHOURS # 0.0 0  AL OPS: HOURS # 151906.4 2397  AL OPS: COSTS = 3417894.4 918191	GHT EVALUATION # 42161.7 525.4  GHT SCFTWARE # 35190.6 239.7  SED MANHOURS # 0.0 0.0  AL OPS: HOURS # 151906.4 2397.4

费	3		
-	1987		
FLIGHTS #	24,0		•
EVEL #	3,0		
01			
PATION =	45,8		
M WTR #	6,0		· · · · · · · · · · · · · · · · · · ·
M-ETR-#	18,0		
RATIONS RE	CURFING	COSTS (ANNUAL)	:
١	ANHCURS	COMPUTER HOU	RS COSTS
ANTING	41828,	500.0	97466473
TROL =	74169,	7 1434.9	2032978,5
LUATION =	45092.	2 561.5	1116080,5
THARE	10105.	501.9	302927.7
HOURS #	C . (	o ö.c	3,0
HOURS #	161050.	4 2618,8	
COSTS	-36236347	9 1003016,0	4626650,9
	FLIGHTS #  EVEL #  ON  RATION #  M WTR #  M ETR #  RATIONS RE  TROL #  LUATION #  TWARE #  HOURS #	RATION = 49.8  M WTR = 6.0  M ETR = 10.0  RATIONS RECURRING  MANHOURS  ANNING = 41828.1  TROL = 74169.1  LUATION = 45092.1  TWARE = 161050.1	FLIGHTS = 24.0  EVEL = 3.0  ON  RATION = 45.8  M HTR = 6.0  M-ETR = 18.0  RATIONS RECURFING COSTS (ANNUAL)  MANHOURS COMPUTER HOU  ANNING = 41828.6 300.0  TROL = 74165.7 1434.9  LUATION = 45092.2 561.5  TWARE = 10105.0 201.9  HOURS = 0.0 0.0

OPTICN	. 3	100 m 100 m 100 m 100 m	
-YEAR	F 1986		
NUMBER OF FLIGHTS	<b>= 19,0</b>		·
AUTGNOMY LEVEL	# 3,C		
NASA MISSION			
MISSION CURATION	= 48,6		•
LAUNCH EFOM HTR	<b>#</b> 4,0		
LAUNCH PROHETE	* 15,0		
FLIGHT OPERATIONS	RECURFING COSTS	(APNUAL)	
	MANHOURS COM	PUTER HOURS	ÇOSTS
HISSION-FLANNING-	<del>- 39336,7</del>	326,0	9110137
FLIGHT CONTROL	<b>≖</b> 5675€,8	1050.9	1537657,
FLIGHT EVALUATION	= 42917,5	453,3	1031947,
-FLIGHT-SCFTHARE	13961,3	203,4	4254397
UNUSED MANHOURS	<b>=</b> ¢,0	0.0	3.
TOTAL OPS, HOURS	# 139018.9	2034,1	
TOTAL-OPS,COSTS-	312779:17	779007.0	<del>-3906857</del>
OPERATIONS PER/FLT	COSTS = 205624	.1	

:	OPTION	3		
	YEAR	* 1989	· · · · · · · · · · · · · · · · · · ·	
	NUMBER OF FLIGHTS	= 25.0		
	AUTOLOMY LEVEL	# 3,0		
<b></b>	NASA HISSION			
	MISSION CURATION	4.35,4		
	LAUNCH FROM WTR	# 5 <sub>1</sub> 0		
	LAUNCH - FROM- ETK-	= 20,0		
	FLIGHT OFERATIONS	RECURFING	COSTS (ANNUAL)	
		HANHOURS	COMPUTER HOURS	COSTS
	HISSION-FLANKING	<del>- 43277</del>	.4 365,3	1005470,2
	FLIGHT CONTROL	# 65120	*	1748721,1
	FLIGHT EVALUATION	= 42298	,4 542,0	1053541,5
	FLIGHT SCHTWARE	F 15065	7 230,5	464941,6
	UNUSED MARHOURS	# C	.0 0.0	Ü, O
	TOTAL CPS, HOURS	= 150696		
	TOTAL OFS, COSTS	F-339067	4 882000,0	4272674.3
	OPERATIONS PERFELT C	OSTS =	170907.0	-

•	OPTION			# .	3					
٠.	YEAR-				1990			·		-
	NUMBER	QF !	FL IGHTS	· ·	22,0					
	AUTONOH	Y LE	VEL.	. 5	3,0					_
, <del></del> .	NASAM	15510	<del>\</del>			<del></del>				
	HISSION	EUR,	TION		37,5			•		
	LAUNCH	FRCM	WTR	#	4,0				·	
•	LAUNCH"	- FACH-	ETR		18,0		·		<del></del>	
	FLIGHT	OPER	TIONS	RE	CURFING	COSTS	(ANNUA	L)		
		•		1	ANACURS	CO	HFUTER	HOURS	COSTS	}
	MISSION	FLAI	VN 1 NG-		11486	12	34	6,1	9631017	7
	FLIGHT	CCITI	RCL	<b>#</b>	59844	. 0	106	0.7	1603115	, (
	FLIGHT	EVAL	MOITAL	Ħ	41299	.0	48	4,0	1011563	, 5
-	PLIGHT-	-SCFT1	ARE-	<del></del>	14263	12	21	0 - A	437150	, · §
	UNUSED	MAŅHO	URS	*	C	. 0		0.0	, د	, (
	TOTAL	ufs,	HOURS	*	142631	,2	210	3,7		
	TOTAL	0P\$ <sub>X</sub>	-C05 <del>75-</del>		<del>-3</del> 20 <del>9201</del>	<del></del>		8,0	49149307	7
	0056471	rins De	6/F1 <b>7</b>	rns	iT5 =	18249				

OPTICN = 3 - DOD BUY	
TOTAL PROGRAM COSTS	٠
NUMBER OF FLIGHTS #208.0	
AUTOKONY LEVEL # 3,0	
NASA - MISSION	
LAUNCH ERCH HTR = 37.0	
LAUNCH EFCM ETR #175.0	
FLICHT CFERATIONS RECURRING COSTS (NASA ONLY)	*.* .*.
MANHOURS COMPUTER HOURS COSTS	
MISSION FLANNING = 392899.0 3370.9 9149023.9	
FLIGHT - CCHTROL - 816707.3 11932,4 20751066,2	
FLIGHT EVALUATION = 372672.0 4662.7 9239242.0	
FLIGHT SCFTWARE # 158227.8 2174.0 4768336.7	
UNUSED MANHOURS 218980,8 U.D 4371619,4	
TOTAL CPS. HOURS = 1582278.4 21740.0	•
TOTAL OFS, COSTS = 35601263.6 8326407.2 43927673.7	
OPERATIONS PER/FLT-COSTS - 211190.7	
FLIGHT OPERATIONS NON-REGURRING COSTS (TOTAL PROGRAM FOR BOTH DOD THASA)	
MANHOURS COMPUTER HOURS COSTS	•
HISSION	-
FLIGHT CONTROL # 52263.9 0.0 1175938.2	
FLIGHT EVALUATION # 0,0 0.0	
FLIGHT SOFTWARE = 178005.2 3122.3 5200963.6	
TOTAL DDT E HOURS # 709133.7 5130.3	
TOTAL DDT E COSTS = 15955509.0 1964904.9 17920429.0	

OPTION	# 3 DOD BUY	
YEAR-	e-1981	
NUMBER OF FLIGHTS	<b>7</b> 7 10	
AUTONOMY LEVEL	# 3 <sub>10</sub>	
DOD HISSION		· · · · · · · · · · · · · · · · · · ·
HISSION DURATION	<b># 39,6</b>	
LAUNCH FROM WTR	<b>#</b> 0.0	
LAUNCH-FROH-ETR-	-a-7 <sub>10</sub>	
FLIGHT OPERATIONS	RECURRING COSTS (ANNUAL)	
	MANHOURS COMPUTER HOURS	COSTS
HISSION-PLANNING		-481789 <sub>1</sub> 6
FLIGHT CONTROL	<b>a</b> 92289,8 493,8	2034916,9
FLIGHT EVALUATION	# 11901,6 156,6	298009,2
FLIGHT SOFTWARE		347412 <sub>1</sub> 9
UPUSED MANHOURS	a 70876.7 0.0	1417534,3
TOTAL OPS, HOURS	# 124800,0 924,6	
TOTAL-OPS GOSTS-	<del></del>	-3162128,6
ACCOUTTANC DED AN T	COSTS # 451732.7	

OPTION	# 3		
-YEAR	-1982		<u></u>
NUMBER OF FLIGHTS	= 10.0		
AUTONOMY LEVEL	# 3 <sub>1</sub> 0		
DOD MISSION	· · · · · · · · · · · · · · · · · · ·		
HISSION DURATION	# 39 <sub>1</sub> 8		
LAUNCH FROM WTR	# 0.0		
- LAUNCH-FROM-ETR-	10 <sub>10</sub>		
FLIGHT OPERATIONS	RECURRING CO	STS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
_HISSIONPLANNING	_=22A <b>95_</b> F_	205;6	536639,6-
FLIGHT CONTROL	84877,2	707,3	1968440,8
FLIGHT EVALUATION	± 17527,3	224,0	426355,2
- FLIGHT-SOFTWARE-	12485-	126,3	36g38 <u>1</u> _7_
UNUSED MANHOURS	s 54223,1	0.0	1084462,0
TOTAL OPS, HOURS	<b>124800.</b> 0	1263,2	
-TOTAL -OPSCOSTS-	<del>=</del> 28 <del>08560_*</del>	483817,4	3291817-74-
OPERATIONS PER/FLT			

OPTION	<b>3</b>		
YEAR	# 1983		
NUMBER OF FLIGHTS	= 15.0		
AUTONOMY LEVEL	# 3.0		¥ .
-DODMISSION			
HISSION DURATION	= 42,9		
LAUNCH FROM WTR	<b>4</b> 4.0		
-LAUNCH-FROH-ETR-	# 11:0		
FLIGHT OPERATIONS	RECURRING COS	TS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
-MISSION PLANNING-	<del>28}6519</del>	25 <sub>11</sub> 7	657704-4
FLIGHT CONTROL	70610,2	1053,6	1815717.3
FLIGHT EVALUATION	s 26123,9	343,7	654127,6
FLIGHT-SOFT ARE	<del>4 12486 18 -</del>	18312-	38217 <del>2,</del> 2
UNUSED MANHOURS	g 24681,5	0,0	493629,6
TOTAL OPS, HOURS	F 124800,b	1832,2	
TOTAL-DPS-COSTS-	28 <del>383(0,0</del>	761721-6	3569721 <sub>7</sub> (
OFERATIONS PER/FLT	costs # 233	981.4	

OPTION		Ħ	3			
YEAR		19	84			
NUMBER	OF FLIGHTS	<b>= 18</b>	• 0			·
ALTONOM	Y LEVEL	<b>=</b> 3	• 0			
- DOD -MI	SSION					·
MISSION	DURATION	= 40	,6		* · · · · · · · · · · · · · · · · · · ·	
LAUNCH	FROM WTR	= 1	0			
- LAUNCH-	FROM-ETR-	-4-1-7	· + 0	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	
FLIGHT	OPERATIONS	RECU	RRING CO	STS (ANNUAL	)	·
	<u> </u>	MAP	IHOURS	COMPUTER	HOURS	COSTS
-MISSION	PLANNING-	~=-	35 <del>476_P</del> _	30.9	12	-835568,5-
FLIGHT	CONTROL		58594,1	964	,1	1531115,3
FLIGHT	EVALUATION	8	30329.7	405	,7	771959,1
-FLIGHT-	-SOFTWARE-	<u></u>	- <u>+</u> 2485 <sub>T</sub> ^-	186		383404 <del></del> 8
UNUSED	MANHOURS	*	9540.4	Ō	, 0	196808,3
TOTAL	ops, Hours	\$	124800.0	1864	, 4	
-TOTAL	-0P5		280 <del>8020+6-</del>	714047	7	-352204 <del>7 ,</del> 7
ADE0171	ONS PER/FLT	-007		7/60 7	*	

:OPTION	·	=	3				•	
YEAR		-1	985					
NUMBER OF	FLIGHTS	4 1	3,0	·	· .			
AUTONOMY	LEVEL	ś	3,0					
DODHISS	I ON				<u> </u>			
MISSION I	DURATION	= 4	8,5	v	·			
LAUNCH F	ROH WTR	2	2,0					
LAUNCH-F	ROH-ETR-	1	1,0					
FLIGHT OF	PERATIONS	REC	URRING	costs	(ANNUA	L)		
		MA	NHOURS	COM	PUTER	HOURS	ÇO	575
MISSION-	PLANNING	- <b>Ģ</b>	-31244	3	26	<del>5                                    </del>	7247	83,3
FLIGHT C	ONTROL	•	70002	,5	76	5,1	16930	95,4
FLIGHT E	VALUATION	ė	23753	, 2	30	9,9	5897	60,4
	OFTWARE	-8	12489	<del>-</del>	14	9,4	<del>3688</del>	48-,8
UNUSED M	ANHOURS	<b>E</b> .	32968	1.		0,0	6573	62,7
TOTAL OP	S. HOURS	8	124500	. 6	148	4,3		
	scosts	- <del>0</del>	-58083 <del>6</del> #	, <u>è</u>	5684E	7.79	-33764	87-9
OPERATION	S PER/FLT	COSI	'S #	250729	7.8			

: OPTION	<b>3</b>		
YEAR	1986		
NUMBER OF FLIGHTS	= 17.0		
AUTONOMY LEVEL	<b>3,</b> 0		
DODHISSION			
MISSION DURATION	= 36,4		
LAUNCH FROM WTR	<b>4</b> 5,0		
-LAUNCH-FROM-ETR-	12-0	·	
FLIGHT OPERATIONS	RECURRING	COSTS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
MISSION-PLANNING-	34446	£ 297 <sub>1</sub> 9	803026-,4
FLIGHT CONTROL	<b>=</b> 62132,	§ 854,4	1569865,8
FLIGHT EVALUATION	= 28221,	9 371,3	706662,2
-FLIGHT-SOFTWARE-	124891	6	376839 <del>-</del> 4
UNUSED MANHOURS	17436,	4 0,0	348727,1
TOTAL OPS, HOURS	₹ 1245¢Ö,	č 1692,9	and the plant of the second
-TOTAL	_=28 <del>0</del> 8560-	648393 <sub>1</sub> 8	3456393 <sub>7</sub> 8
OPERATIONS PER/FLT	costs =	203317.3	

	: OFTION	<b>7</b> 3		
	YEAR	<b>=-1</b> 98 <del>7</del>		
,	NUMBER OF FLIGHTS	# 16.3		
•	AUTONOMY LEVEL	<b>* 3,</b> 0		
	- DOD MISSION-		<del></del>	
	MISSION DURATION	= 47.3		· · · · · · · · · · · · · · · · · · ·
•	LAUNCH FROM WTR	<b># 2.</b> 0		4
	LAUNCH-FROM-ETR-	-14-0	·	·
	FLIGHT OPERATIONS	RECURRING COSTS (AN	NUAL)	
		MANHOURS COMPUT	ER HOURS	COSTS
		- 3625 <del>1 12</del>	294,4	-838538,6
	FLIGHT CONTROL	# 47418,4	872,1	282392,3
	FLIGHT EVALUATION	46733,6	378,3	959546,2
	FLIGHT-SOFTWARE	<del>1</del> 2449 <sub>1</sub> 3	17179-	-376831,7
	UNUSED MANHOURS	in a sign of the sign of	Ø <b>,</b> O	0,0
	TOTAL OPS, HOURS	# 124403 <sub>1</sub> 1	1718,6	
	TOTAL OPST GOSTS-	279 <del>95</del> 7 <del>0+66</del> 5	823 <del>872</del>	457308-8
	OPERATIONS PER/FLT	OSTS # 216081.8		

OPTION	<b>3</b>		
YEAR-	= 1988		
NUMBER OF FLIGHTS	= 18.3		-
AUTONOMY LEVEL	<b>3</b> ,0 ·		•
DOD-HISSION			
HISSION DURATION	= 39,1		
LAUNCH FROM WTR	* 2.0		
LAUNCH-FROM-ETR-			
FLIGHT OPERATIONS	RECURRING COS	TS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
-HISSION-PLANNING	3886212	314,6	88173 <del>8,6</del>
FLIGHT CONTROL	s 50331,1	888,9	1347077.3
FLIGHT EVALUATION	a 39533,5	401,2	944330,0
FLIGHT SOFTWARE	1279217	17973	388107-,0
UMUSED MANHOURS	5 0.8	ŏ. 0	0,0
TOTAL OPS, HOURS	# 127926,R	1783,0	
TOTAL-OPS-COSTS	28783 <b>53</b> 12	<del>68</del> 289 <del>9,7</del>	356125 <del>2,0</del>
OPERATIONS PER/FLT			

OPTION	<b>2</b>		
YEAR	<del>= 1989</del>		
NUMBER OF FLIGHTS	= 16.0		
AUTONOMY LEVEL	<b>3.</b> 0		
DOD-HISSION-			
MISSION DURATION	= 51,2		
LAUNCH FROM HTR	<b>a</b> 4.0		
LAUNCH-FROH-ETR	12.0		
FLIGHT OPERATIONS	RECURRING CO	STS (ANNUAL)	
	MANHOURS	COMPUTER HOURS	COSTS
HISSION-PLANNING-	362316	295,7	837904 <del>-5</del>
FLIGHT CONTROL	# 48483,7	910,3	1318312,8
FLIGHT EVALUATION	# 41841,9	385,6	985653,8
FLIGHT-SOFTWARE-	1245574	477,2	384250,7
UNUSED MANHOURS	g	0.0	0,0
TOTAL OPS, HOURS	= 126554,2	1771,9	,
TOTAL-OPST-GOSTS-		<del>6</del> 78653 <sub>7</sub> 1	3526121 <sub>1</sub> 9
OPERATIONS PER/FLT	_	(6382,6	

:OPTION	<b>3</b>		•
-YEAR	<del>-</del> 1993		
NUMBER OF FLIGHTS	# 18.0	· · · · · · · · · · · · · · · · · · ·	
AUTONOMÝ LEVEL DOD HISSION	m 3,0		
HISSION DURATION	= 40.7		
LAUNCH FROM WTR	# 1.0		
LAUNCH-FROH-ETR-	<del>4 17 10</del>		. *
FLIGHT OPERATIONS	RECURRING COSTS	(ANNUAL)	·
. *	MANHOURS CO	MPUTER HOURS	COSTS
-HISSION-PLANNING-	<del>• 38039<sub>1</sub>6</del>	314 <sub>1</sub> 3	881153-6
FLIGHT CONTROL	# 50802.3	906.4	1363214.6
FLIGHT EVALUATION	m 405c1,6	406,0	955510,6
FLIGHT-SOFTWARE-	_=1284_3	180 <sub>1</sub> 7	39 <u>1</u> 33 <del>1   9</del>
UMUSED MANHOURS	<b>■</b> 0.6	Ó,0	0.0
TOTAL OPS, HOURS	E 128843,4	1807,4	
-TOTAL-OPS-COSTS-	289 <del>8977,2</del>	<del>69</del> 2233 <sub>7</sub> 5	3591210 <del>+7</del>

OPTION			4	3 - DOD	BUY		
TOTAL	PROGRA	IH COS	<del>13</del>				
NUMBER	OF F	FLIGHTS	=14	8.0			
AUTONOM	Y LEV	/EL	#	3,0			
- DOD - H I	581.04-				· · · · · · · · · · · · · · · · · · ·		
LAUNCH	FROM	WTR	<b>#</b> 2	1.0		garage and see the second	
LAUNCH	FROM	ETR	*12	7,0			•
-FLIGHT-	-OPERA	TIONS-	-REC	URRING CO	STS (DOD ONLY	}	
			MA	NHOURS	COMPUTER HOURS	COSTS	
MISSION	PLAN	NING		321715,2	2727,1	7478847,3	
-FL-IGHT-	-CONTR	10L	<del></del>	-655341-2-	8415,0	<del>-15</del> 924148 <del>,5</del>	
FLIGHT	EVALU	JATION	<b>.</b>	299763,2	3385,3	7291914,6	
FLIGHT	SOFTW	IARE	4	125652,8	1614,3	3759581.0	
-UNUSED	<del>-                                      </del>	)urs	<del></del>	<del>-20362512-</del>		<del></del>	·
TOTAL	ops.	HOURS	2	1256527.5	16142,6		
TOTAL	oPS.	COSTS	<b>#</b> 2	8271967.8	6162621,6	34454491,4	
	ONS-PE	R/FLT-	<del>:05</del> 7	S23	280016		
-OPERATI	. ~						
			401	-REGURRING	COSTS (TOTAL P	RCGRAH FOR BOTH O	OD THA
				REGURRING	COSTS (TOTAL P		OD TNA
FLIGHT	OPERA'		M				OD TNA
FLIGHT	OPERA	TIONS N <del>nin</del> é	M	478764 (6	COMPUTER HOUR	s costs	OD THA
FLIGHT —MISSION	OPERA'	TIONS N <del>nin</del> é	H/	478764 6	COMPUTER HOUR	S COSTS —11543527,2	OP TNA
FLIGHT FLIGHT	OPERA'  N_PLA  CONT	TIONS  NNING  ROL  UATION	H/	478764 re- 52263.9	COMPUTER HOUR	S COSTS	OD TNA
FLIGHT FLIGHT	OPERA'  N_PLA  CONT	TIONS  NHING  ROL  UATION  WARE	H/	478764.6 52263.9	COMPUTER HOUR 2009,0 0,0 0,0	\$ COSTS -11543527,2 1175938.2 0,0	OD TNA

32A-11/12-01-01 Perform Malfunction Analyses and Prepare Contingency Profiles

Description: Includes identification of possible failure modes and effects and develops alternate flight profiles to accomplish mission objectives. This is a one time effort for each configuration and increases according to the configuration complexity. Autonomy level, rendezvous and docking, and payload spin-up are used to measure this complexity. Rationale:

During the 18 months preceding IOC, this task requires 5 men for the first 6 month period, 4 men for the second and 1 man for the third. The task also requires 260 computer hours. Ref Config:

Equation: (10,400 MH + 344 CH) AIxRDxSPxPP

WBS 32A-11/12-01 Mission Planning

32A-11/12-01-02 Prepare Abort Profiles

Identify the abort modes for the Tug and the Tug/Shuttle operations and prepare abort Description:

profiles for all abort modes.

This item requires an initial effort for each type of mission. This effort increases Rationale:

according to configuration complexity and is measured by autonomy level, rendezvous

and docking, and payload spin-up.

The initial effort is estimated to require 1 man for the 30 months preceding 10C plus 68 Ref Config:

Computer hours.

Equation: (5200 MH + 68 CH) AIxRDxSPxPP

32A-11/12-01-03 Develop Flight Mission Rules and Supporting Data

Analyze mission objectives in context with flight hardware performance capabilities and Description:

limitations to identify all necessary guidelines and constraints for mission accomplish-

ment. List all these rules in a document.

This is a one time effort which increases with retrieval and/or spin-up capability addition. Rationale:

For the 30 months preceding IOC this task requires 10 men for the first 12 months and 20 Ref Config:

men for the next 18 months plus 260 computer hours.

iquition: (83,200 NH + 344 CH) RDxSPxPP

WBS 32A-11/12-01 Mission Planning

32A-11/12-01-04 Prepare Command Handbook

Analyze on orbit functions to determine necessary commands, examine communication hardware Description:

to determine command mechanization and prepare a handbook containing all the information

required to accomplish command control of the Tug.

This is primarily a one time effort which decreases with increasing levels of autonomy

and increases with retrieval and/or spin-up capability.

This item requires 5 men for the 12 months preceding IOC plus 260 computer hours. Ref Config:

Equation: (10,400 MH + 344 CH) ADXRDxSPxPP

32A-11/12-01-05 Prepare Systems Procedures and Checklists

Analyze systems, subsystems, and interfaces to determine operational and checkout sequences. Description: Transform these data into operating procedures and checklists for use by missions operations

personnel.

This is largely a one time effort which increases with configuration complexity as measured Rationale:

by autonomy level, retrieval, and spin-up capability.

This task requires 10 men for the 12 months preceding IOC. Ref Config:

Equation: (20,800 MH) AIXRDXSPXPP

WBS 32A-11/12-01 Mission Planning

32A-11/12-01-06 Prepare Flight Instrumentation List

Analyze instrumentation system capabilities and establish a list of all the parameters to Description:

be instrumented showing the type, location, sampling rate, coding, range, etc.

This consists of an initial effort which increases with retrieval and spin-up capabilities. . Rationale:

This task requires 3 men for the 12 months period beginning 3 years prior to 10C. Ref Config:

Equation: (6240 MH) RDxSPxPP

32A-11/12-01-07 Prepare Flight Control Operational Data Handbook

Assembly detail technical information on all components and prepare descriptions, Description:

performance charts and other pertinent data in book form.

This is a one time effort which increases with configuration complexity, and; therefore,

increasing autonomy level, retrieval, and spin-up.

During the 24 months preceding IOC this task requires 6 men for the first 12 months and 2

men for the second 12 months.

13tion: (16.640 MH) AIXRDXSPXPP

32A.11/12-01-08 Prepare System Schematics including Vehicle Systems Handbook

Includes preparation of schematic drawings for all Tug vehicle systems. Description: This is a one time effort which increases with configuration complexity and is measured by Rationale:

increasing autonomy level, retrieval, and spin-up.

This task requires 5 men for the 12 months period beginning 30 months prior to 10C. (10,400 MH) AIXRDXSPXPP Ref Config: Equation:

WBS 32A-11/12-01 Mission Planning

32A-11/12-01-09 Prepare Interface Drawings

Description: Includes preparation of drawings to define both the internal interfaces between

systems and the external interfaces between the Tug and other elements of the STS.

This consists of an initial effort which increases with configuration complexity

as measured by autonomy level, retrieval and spin-up.

During the 30 months preceding IOC this task requires 7 men for the first 12 months

and 2 men for the next 18 months.

(20,800 MH) AIXRDXSPXPP Equation:

32A-11/12-01-10 Plan Launch Schedules

Develop a long range launch schedule to efficiently accomplish the payload mission Description:

model considering payload requirements. Tug performance capabilities, fleet size,

turnaround times, etc.

This consists of an initial effort which is constant for all missions and configurations. Rationale:

This task requires 3 men for the 12 months preceding 10C plus 43 computer hours. Ref Config:

(6240 MH + 43 CH)

Ref Config:

Rationale:

Filght Control . 4, 2 WBS 32A-11/12-02 32A-11/12-02-01 Perform Operations Planning

Description: The overall planning and coordination of the flight operations effort including

determination of manpower, display console, computer, software, training and

facility requirements for the Mission Control Center.

This is a one time effort that decreases with increasing level of autonomy and Rationale:

increases with retrieval capability.

This task requires 10 men for the 18 months preceding IOC. Ref Config:

(31,200 MH) ADXRDXPP Equation:

4, 3 WBS 32A-11/12-04 Flight Support Software

32A-11/12-04-01 Develop Computer Program for Mission Planning

Development of a computer program to be used for determining mission trajectories and Description:

related mission planning functions such as ground communication opportunities.

This is a one time effort essentially the same for all configuration's and missions but Rationale:

increases for retrieval capability.

Requires 6 men for 1 year beginning 42 months prior to IOC plus 203 computer hours.

lation: (12,480 MH + 407 CH) RD

32A-11/12-04-02 Develop Computer for Flight Control

Development of a computer program to be used for determining vehicle control requirements Description:

for satisfying the desired trajectory, performing error analyses, and generating guidance

and control constants.

This is a one time effort that decreases with autonomy level and increases with retrieval

and spin-up.

Requires 6 men for 2 years beginning 42 months prior to IOC plus 415 computer hours. Ref Config:

12tion: (24,960 FM + 830 CH) ADXRDxSP

32A-11/12-04-03 Develop Flight Operations Simulation

Development of a software program for simulating the complete spectrum of filght Description:

operations to accomplish operations crew training and to evaluate and resolve inflight

malfunctions. Also, to substantiate guidance and control constants.

This is a one time effort that decreases with autonomy level and increases with mission

duration, retrieval and spin-up.

During the 30 months prior to IOC this task requires 15 men for the first 18 months,

men for the next 6 months and 7 men for the last 6 months plus 1385 computer hours.

Equation: . (62,400 PH + 1385 CH) ADXIDXRDXSP

WBS 32A-11/12-04 Flight Support Software (Cont.)

32A-11/12-04-04 Prepare Shuttle Flight Support Software

Description: Covers the development of a general program to satisfy the software interface between the

Tug and the Orbiter for activation, checkout, command, separation, docking, etc.

Requires 3 men for 1 year beginning 24 months prior to IOC plus 104 computer hours. This is a one time effort essentially the same for all configurations and missions. Ref Config: Rationale:

(6240 MH + 208 CH) Equ: tion: 32A-11/12-04-05 Develop Real Time Mission Software

Development of software program for performing onboard functions of fault isolation, docking. Description:

stationkeeping, radar processing, mission planning, targeting, position/velocity update.

and redundancy management, and evaluating mission success.

This is a one time effort that increases with autonomy level, retrieval, and spin-up. Rationale:

Requires 5 men for 2 years beginning 42 months prior to IOC plus 200 computer hours. Ref Config:

(41,600 MH + 746 CH) AIXRDXSP Equation: 32A-11/12-04-06 Develop Post Flight Evaluation Software

Description: Development of software program to provide for automatic comparison of post flight

instrumentation data with nominal predictions plus tolerances for each parameter

This is a one time effort essentially the same for all configurations and missions. Rationale:

Requires 6 men for 2 years beginning 30 months prior to IOC plus 415 computer hours. Ref Config:

24,960 MH + 830 CH

### 4.4 Facilities (Non-Recurring)

The facilities required to perform orbital flight operations for both NASA at Houston, and DOD at Sunnyvale, were assumed for the Space Tug Study to be currently available at the respective mission control center. As a result of this assumption facilities costs for orbital flight operations are not included in the present cost model for the Space Tug.

WBS 32C-11/12-01 Mission Planning

32C-11/12-01-01 Prepare Flight Plan

Includes preparation of flight profiles, timelines, trajectories, mass histories, ground Description:

traces, etc., using the basic computer program for mission planning developed under

Flight Support Software.

This effort is required for each flight and increases with mission complexity including Rationale:

rendezvous and docking. Mission duration is used as the measure of complexity.

It was estimated to require three men for one month plus 6 hours of computer time to Ref Config:

prepare each specific mission flight plan.

(519 PH + 6 CH) MDXNF + (104 PH + 1.2 CH) NFRD Equation: 32C-11/12-01-02 Perform Malfunction Analyses and Prepare Contingency Profiles

Includes identification of possible failure modes and effects and develops alternate Description:

flight profiles to accomplish mission objectives.

This is essentially a continuing effort for each configuration and increases according to Rationale: the configuration complexity. Autonomy level, rendezvous and docking, and payload spin-up

are used to measure this complexity.

This task requires a continuing level of 1 man for 11 years plus 344 computer hours. Ref Config:

(2,080 MH + 31.3 CH) AIXRDXSPXPD Equation:

WBS 32C-11/12-01 Mission Planning (Cont.)

32C-11/12-01-03 Prepare Abort Profiles

Description: Identify the abort modes for the Tug and the Tug/Shuttle operations and prepare abort

profiles for all abort modes.

This item requires an effort for each specific flight. This effort increases according

to configuration complexity and is measured by autonomy level.

The effort is estimated to require I man month plus 2 computer hours for each flight. Ref Config:

(173 MH + 2 CH) AIXNF + (35 MH + 0.4 CH) AIXNFRDXSP Equation:

32C-11/12-01-04 Develop Flight Mission Rules and Supporting Data

Description: Analyzes mission objectives in context with flight hardware performance capabilities

and limitations to identify all necessary guidelines and constraints for mission

accomplishment. Lists all these rules in a document.

This is an effort essentially the same for all configurations except those with rendezvous

and docking which require an increased effort.

This task requires 2 men for 11 years plus 172 computer hours. Ref Config:

Equation: (4,160 MH + 172 CH) RDxPDxSP

WBS 32C-11/12-01 Mission Planning (Cont.)

32C-11/12-01-05 Prepare Systems Procedures and Checklists

Analyze systems, subsystems, and interfaces to determine operational and checkout sequences. Description:

Transform these data into operating procedures and checklists for use by missions operations

personnel.

This is a continuing effort which increases with configuration complexity as measured by Rationale:

autonomy level, rendezvous and docking, and spin-up capability.

This task requires 2 men for 11 years. Ref Config:

(4,160 MH) AIXRDXSPXPD Equation: 32C-11/12-01-06 Prepare Flight Instrumentation List

Analyze instrumentation system capabilities and establish a list of all the parameters to Description:

be instrumented showing the type, location, sampling rate, coding, range, etc.

This consists of a low level continuing effort and is essentially constant for all Rationale:

configurations except those with rendezvous and docking which require an increased effort.

This task requires 1 man for 13 years. Ref Config:

(2,080 MH) PDxRDxSP Equation:

WBS 32C-11/12-01 Mission Planning (Cont.)

32C-11/12-01-07 Prepare Flight Control Operational Data Handbooks

Description: Assemble detail technical information on all components and prepare descriptions,

performance charts and other pertinent data in book form.

This is a continuing effort which increases with configuration complexity and, therefore, Rationale:

increasing autonomy level.

Ref Config: Requires 2 men for 11 years.

Equation: (4,160 MH) AIxRDxSPxPD

32C-11/12-01-08 Prepare Interface Drawings

Description: Includes preparation of drawings to define both the internal interfaces between systems

and the external interfaces between the Tug and other elements of the STS.

This consists of a continuing effort for the life of the program. It increases with Rationale:

configuration complexity as measured by autonomy level, retrieval, and spin-up.

Ref Config: Requires 2 men for 11 years.

Equation: (4,160 MH) AIxRDxSPxPD

WBS 32C-11/12-01 Mission Planning (Cont.)

32C-11/12-01-09 Plan Launch Schedules

Description: Develop a long range launch schedule to efficiently accomplish the payload mission model

considering payload requirements. Tug performance capabilities, fleet size, turnaround

times, etc.

This consists of a low level continuing effort for both ETR and WTR, which is constant Rationale:

for all missions and configurations.

Requires 1-1/2 men for 11 years for ETR and 1/2 man for 11 years for MTR. Ref Config:

Equation: (4,160 MH + 27.3 CH) PD

4.6 WBS 32C-11/12-02 Flight Control

32C-11/12-02-01 Analyze Flight Control Requirements for Ground Commands and Control Measurements

Description: Analyze the Flight Plan to determine what commands and control measurements are required.

when ground access is available and from what stations commands will be transmitted and

measurement data received.

This effort is required for each flight and increases with increasing mission duration Rationale:

and retrieval and spin-up, and decreases with increasing level of autonomy.

Requires 2 men for 6 weeks plus 1 computer hour for each flight. Ref Config:

(480 MH + 1 CH) ADXMDXNF + (96 MH + 0.2 CH) NFRDXADXSP Equation: 32C-11/12-02-02 Run Computer Programs for Flight Control Including Guidance and Error Analysis

Description: The computer programs developed under Flight Support Software will be run for each

specific flight to determine subsystem level data required for flight control functions

such as power management data dump, altitude, pointing, and payload analysis.

the flight tape will be generated and an error analysis of the flight tape will be performed.

This effort is required for each flight and increases with mission duration and retrieval Rationale:

and spin-up.

Requires 4 men for 6 weeks plus 5 computer hours for each flight. Ref Config:

Equation: (960 MH + 5 CH) MDXNF + (192 MH + 1 CH) NFRDxSP

WBS 32C-11/12-02 Flight Control (Cont.)

32C-11/12-02-03 Perform Real (and Delayed) Time Flight Control

Covers the flight controllers required to man the display consoles in the Mission Control Description:

Center for monitoring the vehicle, trajectory and engineering data, executing command

control of all required on orbit functions, evaluating the accomplishment of primary

mission objectives, determining the need for implementing alternate, contingency or abort

flight modes and updating the flight plan.

This effort is required per flight and starts one day before the launch and continues Rationale:

until Orbiter landing. It decreases with increasing level of autonomy and increases with

mission duration.

Requires 6 men for 32 hours plus the mission duration plus use of a dedicated computer Ref Config:

for same length of time for each flight.

uation: [(16 + MT) 6 MH + (16 + MT) CH] ADXNF

32C-11/12-02-04 Analyze and Resolve Inflight Anomalies

Covers the technical personnel required to support the flight controllers by analyzing flight Description:

data anomalies and determining their cause and effect.

This effort is required for each flight from one day prior to launch until Orbiter landing and decreases with increasing level of autonomy and increases with mission duration.

Requires 14 men for 32 hours plus the mission duration for each flight. Ref Config:

Equation: [(16 + MT) 14 HH] ADXNF

# 108 326-11/12-02 FAJA CAREL (CLICHT OPERATIONS

WBS 32C-11/12-02-05 Support Fre-Launch Checkout

Description: Covers the Mission Control Center support of the Tug pre-launch checkout to verify

MCC/Tug interfaces and calibrations.

This effort is required for each flight and decreases with increasing autonomy level. Rationale:

Requires 20 men for 8 hours plus use of a dedicated computer for each flight. Ref Config:

(160 MH + 8 CH) ADXNF Equation: WBS 32C-11/12-02-06 Support Launch and Tug Activation

Description: Covers the Mission Control Center support of the final launch checkout. ascent to orbit.

and activation of the Tug by Orbiter crew.

This effort is required for each flight and decreases with increasing level of autonomy. Rationale:

Requires 20 men for 4 hours for launch support and 20 men for 4 hours for ascent and Tug Ref Config:

activation plus a dedicated computer.

(160 MH + 8 CH) ADXNF

WBS 32C-11/12-03 Flight Evaluation

32C-11/12-03-01 Perform Flight Data Reduction

Description: Transform raw flight TM and onboard recorded data into useful engineering form by

of computer.

This task is required for each flight and increases with mission duration. Rationale:

Requires 2 men for 2 weeks. Most of the effort is accomplished automatically requiring Ref Config:

10 computer hours per flight.

(160 MH + 10 CH) MDXNF Equation: 32C-11/12-03-02 Perform Post Flight Data Analysis

Description: This consists of a computer comparison of filght instrumented parametric data with nominal

data to identify and isolate all out-of-tolerance conditions.

This task is required for each flight and increases with mission duration. Rationale: The bulk of the Requires 2 men for 2 weeks plus 10 hours of computer time per flight. Ref Config:

effort is automatically performed.

(160 PH + 10 CH) MDXNF Equation:

WBS 32C-11/12-03 Flight Evaluation (Cont.)

32C-11/12-03-03 Resolve Data Anomalles

Description: Analyze the flight data anomalies identified by the computer comparison and determine

the cause and effect so that corrective action can be undertaken if necessary.

This task is required for each flight and increases with mission duration. Rationale:

Requires 8 men for 2 weeks plus 2 computer hours per flight. Ref Config:

(640 MH + 2 CH) MDXNF Equation: 32C-11/12-03-04 Prepare Flight Evaluation Report

Description: Prepare a final report of the flight data analysis which evaluates mission accomplish

and system performance and identifies problems encountered.

Required for each flight and increases with mission duration. Rationale:

Requires 3 men for 4 weeks for each flight. Ref Config:

(480 MH) MDXNF Equation:

4,4 WBS 32C-11/12-04 FLIGHT SUPPORT SOFTWARE

32C-11/12-04-01 Mission Planning Software Changes

Covers the changes to the mission planning software that result from requirement, design Description:

and program changes.

This is a continuing effort for the life of the program. Rationale:

This task is estimated at 10% of the effort required for the mission planning tasks Ref. Config:

(320-11/12-01).

Mission Planning MHx0.1 + Mission Planning CH x0.1 Equation:

32C-11/12-04-02 Flight Control Software Changes

Covers the changes to the flight control software that result from requirement, design Description:

and program changes.

This is a continuing effort for the life of the program. Rationale:

This task is estimated at 10% of the effort required for the flight control tasks. Ref. Config:

(320-11/12-02).

Equation: Flight Control MHx0.1 + Flight Control CHx0.1

WBS 32C-11/12-04-03 Flight Evaluation Software Changes

Covers the changes to the flight evaluation software that result from requirement, design Description:

and program changes.

This is a continuing effort for the life of the program. Rationale: This task is estimated at 10% of the effort required for the flight evaluation tasks Ref. Config:

(32C-11/12-03).

Flight Evaluation MHx0.1 + Flight Evaluation CHx0.1. Equation:

### 4.9 Network Operations Costs

Subsequent to the Concept Selection the COR directed that the network operations cost be removed from the flight operations cost estimates and that network utilization requirements be calculated instead. See Section 6.8 for the results of the network utilization requirements calculations.

### 5.0 SHUTTLE REQUIREMENTS

The operational requirements placed upon the Shuttle Orbiter are those concerned with (1) the structural and mechanical hardware used in support of Tug/payload deployment and retrieval operations, (2) the crew involvement in check out, monitoring, safing and passivation operations, deployment and retrieval manipulation, visual observations via closed-circuit TV, caution and warning displays and corrective system controls, and (3) the data management system interfaces, hardware and software, including computer support requirements by the Orbiter computer and the dedicated payload computer capability.

### 5.1 Deployment/Retrieval Timelines

The condensed operational timelines for Tug handling are shown in Table 5.1-1 (deployment of one or more payloads with a single Tug) and Table 5.1-2 (retrieval of a Tug alone or a Tug with payloads). The expanded timelines provided in Table 5.1-3 are representative for all deployment or retrieval mission and are based on the functiona flows presented in Figure 5.1-1.

### 5.2 Crew and Shuttle Functions

The crew functions are basically defined for a four-man crew, considering the Orbiter, Tug and Payload requirements. A review of these crew functions was conducted to consider four-man and smaller crew complements. The results are summarized in Figure 5.2-2 and the crew/Shuttle functions listed on the crew-size impact assessment charts. It was determined that a three-man crew can physically manage the dual functions of payload and Tug operations, plus the monitoring functions of the Orbiter, if the Orbiter has autopilot control and operates in a powered-down quiescent mode on-orbit. A common MSS/PSS console would better accommodate this option and would release the commander. However, a very desirable increase in operational flexibility, emergency response

OPERATIONAL TIMELINE

# DEPLOYMENT OF ONE OR MORE P/L WITH TUG

MAN-MIN	48	<b>6</b>	30	20	84	8
CREW		. · <b>2</b>	m	<b>2</b>	2.5	_
TIME-MINUTES	32	, <b>m</b>	10	10	33.5	1.5
OPERATION	PRE-DEPLOYMENT OPNS (ACTIVATE/CHECK/OPEN DOORS)	DISENGAGE/DISCONNECT (ATTACHMENTS/LINES)	DEPLOY AND SEPARATE (ROTATE, ATTACH RMS, REMOVE, DISCONN. ELECT.)	MANIPULATE AND RELEASE	MOVE SHUTTLE AWAY, ACTIVATE PROP./APS, COORBITAL CHECKS, HANDOFF CONTROL	STOW MANIPULATOR
TUG LOCATION	ВАҮ	ВАУ	TILT TABLE	RMS	SHUTTLE PROXIMITY	SEPARATE

8

TOTAL

// Table 5.1-2 OPERATIONAL TIMELINE

## RETRIEVAL OF TUG OR TUG WITH PAYLOADS

	KEIKIEVAL UT 100 UN 100 MIII TAILUADA	מייון בעורמעמי		
TUG LOCATION	OPERATION	TIME-MINUTES	CREW	MAN-MIN
SEPARATE	ORBITER RENDEZVOUS			
	INITIAL TUG MANEUVERS	30	_	30
	STATIONKEEPING	52	_	25
	ORBITER MANEUVERS, SAFE TUG PROP, VENT/ DUMP TUG FLUIDS, VERIFY SAFE TUG	48	<b>N</b> 7,	56
SHUTTLE PROXIMITY	ORBITER/TUG DOCKING PREPARATION, TUG & SHUTTLE MANEUVERS, VERIFY SAFE TUG	23.5	2.5	29
RMS	MANIPULATOR OPERATIONS	22	~	44
RMS	PASSIVATE, VENT/DUMP FLUIDS, VERIFY SAFE TUG, RETRACT	65	2	130
TILT TABLE	MATE/LATCH, CONN. ELECT., STOW RMS, STOW TUG, CONN. LINES	14	8.	<b>58</b>
ВАУ	PREP. TUG/PL FOR RETURN	17	<b>?</b>	39
	IDIAL	6.172		64 1

 $\varphi$  Table 5.1-3

MISSION TIME HISTORY

# DEPLOYMENT OF TWO PAYLOADS AND RETRIEVAL OF ONE

### SYNCHRONOUS EQUATORIAL ORBIT

	MISSION PHASES AND EVENTS	LIFTOFF	CIRCULARIZE IN 160 NM ORBIT (ORBITER)	PHASING COAST (ORBITER)	PERFORM PRE-DEPLOY OPERATIONS	ACTIVATE & CHECK TUG SUBSYSTEMS EXCEPT PROPULSIVE (ORBITER)	ALIGN ORBITER IMU. UPDATE STATE VECTOR (ORBITER)	ORIENT FOR TUG DEPLOYMENT (ORBITER)	VERIFY PAYLOAD READINESS (GROUND/ORBITER)	ALIGN TUG IMU TO ORBITER IMU (ORBITER/TUG) OPEN PAYLOAD BAY DOORS LOAD TUG COMPUTER WITH UPDATED STATE VECTOR (ORBITER/TUG)	DISCONNECT VENT LINE CONNECTOR (ORBITER)	DISENGAGE STOWAGE RETENTION DEVICES (ORBITER)	DEPLOY AND SEPARATE TUG	DEPLOY TUG FROM CARGO BAY (ORBITER)	ACTIVATE/UNSTOW MANIPULATOR. ENGAGE TUG (ORBITER)	VERIFY PHYSICAL ATTACHMENT INTEGRITY (ORBITER)	
	EVENT DURATION HR:MN:SC	00:00:00	00:03:00	00:00:80		00:15:00	00:00:00	00:01:00	00:02:00	00:03:00 00:03:00 00:01:00	00:01:00	00:01:00		00:02:00	00:05:00	00:01:00	
•	EVENT START TIME HR:MN:SC	00:00:00	03:05:00	03:02:00		11:05:00	11:05:00	11:20:00	11:21:00	11:21:00 11:21:00 11:24:00	11:25:00	11:26:00		11:27:00	11:32:00	11:34:00	
	MISSION EVENT NO.	н		m م		<b>स</b>	5-	4	-	- <b>8</b> 8 € €	r ()	11	·	12	13	77	

Table 5.1-3
Sheet 2

MISSION   PARMS FRAME   DIRACTION   PARMS				
11:35:00   00:01:00   DISCORNECT ELECTRICAL UPELICALS (ORBITER)     11:36:00   00:01:00   DISCORNECT TUC FROM ORBITER ATTACHMENT (ORBITER)     11:37:00   00:08:00   MANIPULATE TUC FROM HANIPULATOR (ORBITER)     11:45:00   00:05:00   UNCOUPLE TUC FROM HANIPULATOR (ORBITER)     11:45:00   00:07:00   PERFORM ORBITER AFS BURN. SEPARATE TO SAFE DISTANCE     11:52:00   00:07:00   VISUALLY INSPECT TUC (ORBITER)     11:55:00   00:00:00   SERBD EMBRIER AFS BURN. SEPARATE TO SAFE DISTANCE     11:55:00   00:00:00   ORBITER AFS - VERIFY     11:55:00   00:00:00   TUG ACTIVATE AFS - VERIFY     11:57:00   00:00:00   TUG ACTIVATE ATTITUDE CONTROL (ORBITER)     11:57:00   00:00:00   TUG ACTIVATE TUC MAIN PROPULSION SUBSYSTEM (ORBITER)     12:04:00   00:00:00   TRANSMIT ATTITUDE CONTROL CAPABILLITY (ORBITER)     12:04:00   00:00:00   TRANSMIT TUC SUBSYSTEMS CHECKOUT DATA     12:13:00   00:00:15   TRANSMIT TUC SUBSYSTEMS CHECKOUT DATA     12:13:00   00:00:15   TRANSMIT TUC SUBSYSTEMS CHECKOUT DATA     12:13:15   00:00:15   RECEIVE MENSION EMBLE - EXECUTE     12:13:30   00:00:15   RECEIVE MENSION EMBLE - EXECUTE     12:13:30   00:00:15   RECEIVE AND STOM MANIPULATOR (ORBITER)	MISSION EVENT NO.		EVENT DURATION HR:MN:SC	MISSION PHASES AND EVENTS
11:37:00 00:01:00 MANIPULATE TUG FROM ORBITER ATTACHMENT (ORBITER) 11:47:00 00:06:00 UNGOUPLE TUG FROM MANIPULATOR (ORBITER) 11:47:00 00:05:00 UNGOUPLE TUG FROM MANIPULATOR (ORBITER) 11:47:00 00:07:00 PERFORM ORBITER APS BURN. SEPARATE TO SAFE DISTANCE 11:52:00 00:07:00 PERFORM ORBITER APS BURN. SEPARATE TO SAFE DISTANCE 11:55:00 00:07:00 SEAD EMBLE/ACTIVATE SIGHAL FOR TUG APS (ORBITER/TUG) 11:55:00 00:00:30 EMBLE TUG ACTIVATE ACTITUDE CONTROL (ORBITER) 11:57:00 00:00:00 11:57:00 00:00:00 11:57:00 00:00:00 11:57:00 00:00:00 11:57:00 DO:00:00 11:5	15	11:35:00	00:01:00	
11:37:00   00:08:00   WANIPULATE TUC TO RELEASE POSITION (ORBITER)     11:45:00   00:02:00   UNCOUPLE TUC FROM MANIPULATOR (ORBITER)     11:45:00   00:07:00   VISUALLY INSPECT TUC (ORBITER)     11:52:00   00:07:00   VISUALLY INSPECT TUC (ORBITER)     11:53:00   00:00:00   TUG ACTIVATE AFS BURN. SEPARATE TO SAFE DISTANCE     11:55:00   00:00:00   TUG ACTIVATE ATTITUDE CONTROL (ORBITER)     11:55:00   00:00:00   TUG ACTIVATE ATTITUDE CONTROL (ORBITER)     11:56:00   00:00:00   TRANSALT ATTITUDE CONTROL CAPABILITY (ORBITER)     11:57:00   00:05:00   TRANSALT ATTITUDE CONTROL CAPABILITY (ORBITER)     12:07:00   00:05:00   TRANSALT TUC ATTITUDE CONTROL CAPABILITY (ORBITER)     12:07:00   00:05:00   TRANSALT TUC SUBSTSTEMS CHECKS (ORBITER)     12:13:00   00:00:05:00   TRANSPER CONTROL TO TUC - MISSION ENABLE (ORBITER)     12:13:30   00:00:13   RECEIVE MISSION ENABLE - EXECUTE     12:13:30   00:00:13   RETRACT AND STOW MANIPULATOR (ORBITER)	16	11:36:00	00:01:00	TUG FROM ORBITER ATTACHMENT
11:45:00   00:02:00   UNCOUPLE TUG FROM MANIPULATOR (ORBITER)     11:47:00   00:05:00   VISUALLY INSPECT TUG (ORBITER)     11:45:00   00:01:00   VISUALLY INSPECT TUG (ORBITER)     11:55:00   00:01:00   VISUALLY INSPECT TUG (ORBITER)     11:55:00   00:00:00   TUG ACTIVATE AFS - VERIFY     11:55:00   00:00:30   EMBLE TUG ACTIVE ATTITUDE CONTROL (ORBITER)     11:55:00   00:00:30   TUG ACTIVATE ATTITUDE CONTROL (ORBITER)     11:57:00   00:00:00   TUG ACTIVATE ATTITUDE CONTROL (ORBITER)     11:57:00   00:00:00   TRANSMIT ATTITUDE CONTROL CAPABILLITY (ORBITER)     12:04:00   00:05:00   VERIFY TUG ATTITUDE CONTROL CAPABILLITY (ORBITER)     12:04:00   00:05:00   VERIFY TUG ATTITUDE CONTROL CAPABILLITY (ORBITER)     12:07:00   00:00:00   TRANSMIT TUG SUBSYSTEMS CHECKS (ORBITER)     12:13:15   00:00:15   TRANSFER CONTROL TO TUG - MISSION EMABLE (ORBITER)     12:13:15   00:00:15   RECEIVE MISSION EMABLE - EXECUTE     12:13:30   00:00:00   RETRACT AND STOW MANIPULATOR (ORBITER)	17	11:37:00	00:08:00	MANIPULATE TUG TO RELEASE POSITION (ORBITER)
11:47:00   00:05:00   VISUALLY INSPECT TUC (ORBITER)     11:52:00   00:01:00   SEND ENABLE/ACTIVATE SIGNAL FOR TUG AFE DISTANGE     11:53:00   00:00:00   TUG ACTIVATE AFS - VERIFY     11:55:00   00:00:30   TUG ACTIVATE AFTITUDE CONTROL (ORBITER)     11:55:00   00:00:30   TUG ACTIVATE ATTITUDE CONTROL (ORBITER)     11:56:00   00:00:00   THANSHUT ATTITUDE CONTROL (ORBITER)     11:57:00   00:00:00   TRANSHUT ATTITUDE CONTROL CAPADILITY (ORBITER)     12:02:00   00:00:00   TRANSHUT ATTITUDE CONTROL CAPADILITY (ORBITER)     12:04:00   00:00:00   TRANSHUT TUC SUBSYSTEMS CHECKS (ORBITER)     12:13:00   00:00:15   TRANSHUT TUC SUBSYSTEMS CHECKS (ORBITER)     12:13:30   00:00:15   TRANSFER CONTROL TO TUC - MISSION ENABLE (ORBITER)     12:13:30   00:01:30   REFERENCE AND STON MANIPULATOR (ORBITER)	ह्य (	11:45:00	00:05:00	UNCOUPLE TUG FROM MANIPULATOR (ORBITER)
11:45:00 00:07:00 11:52:00 00:01:00 11:53:00 00:02:00 11:55:30 00:00:30 11:55:30 00:00:30 11:57:00 00:01:00 12:02:00 00:02:00 12:04:00 00:05:00 12:07:00 00:05:00 12:13:15 00:06:15 12:13:30 00:01:30	ر ا	11:47:00	00:02:00	SEPARATE TO SAFE DISTANCE
11:52:00 00:01:00 11:53:00 00:02:00 11:55:00 00:00:30 11:55:30 00:00:30 11:57:00 00:01:00 12:02:00 00:05:00 12:04:00 00:05:00 12:07:00 00:05:00 12:13:15 00:00:15 12:13:30 00:01:30	50	11:45:00	00:01:00	VISUALLY INSPECT TUG (ORBITER)
11:53:00 00:02:00 11:55:00 00:00:30 11:55:30 00:00:30 11:57:00 00:01:00 12:02:00 00:05:00 12:04:00 00:05:00 12:04:00 00:05:00 12:13:00 00:06:05 12:13:30 00:01:30	21	11:52:00	00:01:00	SEND ENABLE/ACTIVATE SIGNAL FOR TUG APS (ORBITER/TUG)
11:55:00 00:00:30 11:55:30 00:00:30 11:57:00 00:01:00 12:02:00 00:05:00 12:04:00 00:03:00 12:07:00 00:06:00 12:13:15 00:00:15 12:13:30 00:01:30	25	11:53:00	00:05:00	ACTIVATE APS
11:55:30 00:00:30 11:56:00 00:01:00 12:02:00 00:05:00 12:04:00 00:03:00 12:07:00 00:06:00 12:13:00 00:00:15 12:13:30 00:01:30	5-5 83	11:55:00	00:00:30	ENABLE TUG ACTIVE ATTITUDE CONTROL (ORBITER)
11:56:00 00:01:00 11:57:00 00:05:00 12:02:00 00:02:00 12:04:00 00:03:00 12:07:00 00:06:00 12:13:00 00:00:15 12:13:30 00:01:30	77	11:55:30	00:00:30	TUG ACTIVATE ATTITUDE CONTROL
11:57:00 00:05:00 12:02:00 00:02:00 12:04:00 00:03:00 12:07:00 00:06:00 12:13:00 00:00:15 12:13:30 00:01:30	25	11:56:00	00:01:00	TRANSMIT ATTITUDE CONTROL READY SIGNALS
12:02:00 00:02:00 12:04:00 00:03:00 12:07:00 00:06:00 12:13:00 00:00:15 12:13:15 00:00:15	56	11:57:00	00:02:00	VERIFY TUG ATTITUDE CONTROL CAPABILITY (ORBITER)
12:04:00 00:03:00 12:07:00 00:06:00 12:13:00 00:00:15 12:13:30 00:01:30	\ (`)	12:02:00	00:02:00	ENABLE/ACTIVATE TUG MAIN PROPULSION SUBSYSTEM (ORBITER)
12:07:00 00:06:00 TRANSMIT TUG SUBSYSTEMS 12:13:00 00:00:15 TRANSFER CONTROL TO TUG 12:13:15 00:00:15 RECEIVE MISSION ENABLE - 12:13:30 00:01:30 RETRACT AND STOW MANIPUI	28	12:04:00	00:03:00	PERFORM POST-SEPARATION TUG SUBSYSTEM CHECKS (ORBITER)
12:13:00 00:00:15	53	12:07:00	00:90:00	TRANSMIT TUG SUBSYSTEMS CHECKOUT DATA
12:13:15 00:00:15 12:13:30 00:01:30	30	12:13:00	00:00:15	
12:13:30 00:01:30	an S	12:13:15	00:00:15	RECEIVE MISSION ENABLE - EXECUTE
	32	12:13:30	00:01:30	RETRACT AND STOW MANIPULATOR (ORBITER)
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Sheet 3	MISSION PHASES AND EVENTS	MANEUVER TO REQUIRED ATTITUDE FOR ROI BURN	VERIFY SUBSYSTEM READINESS FOR ROI BURN	REPORT STATUS TO MISSION CONTROL	PERFORM ROI BURN (MAIN ENGINE)	REPORT STATUS TO MISSION CONTRCL	PERFORM COAST OPERATIONS	STATIONKEEP	PERFORM ORBITER RENDEZVOUS WITH TUG	ALIGN IMU. UPDATE STATE VECTOR (ORBITER)	ACQUIRE & LOCK-ON TO TUG (ORBITER)	ESTABLISH COMMUNICATION BETWEEN VEHICLES (ORBITER)	TRANSFER TUG FLIGHT CONTROL TO ORBITER. VERIFY (ORBITER/TUG)	RESPOND TO ORBITER COMMUNICATIONS	MANEUVER TUG TO PREFERRED RENDEZVOUS ATTITUDE (ORBITER/TUG)	STATIONKEEP, MAINTAIN ATTITUDE CONTROL	ACTIVATE TUG RENDEZVOUS AIDS (ORBITER/TUG)	CONFIGURE TUG FOR RENDEZVOUS (ORBITER/TUG)	TRANSMIT RENDEZVOUS READINESS SIGNAL	DETERMINE RANGE & RANGE RATE (ORBITER)	
ENDENT	DURATION HR: MX: SC	00:02:00	00:03:00	00:05:00	00:01:35	00:05:00	26:00:00	26:30:00	· ·	00:02:00	00:10:00	00:03:00	00:05:00	00:02:00	00:00:00	00:55:00	00:01:00	00:03:00	00:00:30	00:04:00	-
	TIME HR:MW:SC	126:04:55	126:09:55	126:12:55	126:14:55	126:16:30	126:18:30	126:18:30		152:18:30	152:23:30	152:33:30	152:36:30	152:33:30	152:38:30	152:43:30	152:43:30	152:44:30	152:47:30	152:48:00	
	MISSION .	181	182	183	184	O 185	186	187	· .	ء ج	-6 188	190	191	192	193	101	195	196	197	198	•

Table >.1-3	Sheet 4	MISSION PHASES AND EVENTS	DETERMIKE RENDEZVOUS INTERCEPT MANEUVERS (ORBITER)	COMPUTE IPI BURN PARAMETERS (ORBITER)	MANEUVER ORBITER TO REQUIRED ATTITUDE FOR TPI BURN (ORBITER)	VERIFY ORBITER READINESS FOR TPI BURN (ORBITER)	Perform IPI burn (oms engines) (orbiter)	PERFORM COURSE CORRECTION OPERATIONS (ORBITER)	COMMAND DEACTIVATION/SAFE TUG MAIN PROPULSION (ORBITER)	DEACTIVATE/SAFE MAIN PROPULSION	VERIFY COMPLETION OF MAIN PROPULSION SAFING (ORBITER/TUG)	DETERMINE RANCE & RANCE RATE (ORBITER)	COMPUTE TPF BURN PARAMETERS (ORBITER)	ORIENT ORBITER FOR INITIAL TPF BURN (ORBITER)	VERIFY CRBITER READINESS FOR TPF BURNS (ORBITER)	PERFORM TPF BURNS (OMS/APS ENGINES) (ORBITER)	VENT & DUMP EXCESS TUG FLUIDS (TUG/ORBITER)	VERIFY PAYLOAD SAFE FOR DOCKING (TUG/ORBITER)	PERFORM ORBITER/TUG DOCKING & POST-DOCKING OPERATIONS (ORBITER/TUG)	READY CARGO BAY & MANIPULATOR FOR TUG RETRIEVAL (ORBITER)	
		EVENT DURATION HR:MN:SC	00:05:00	00:03:00	00:02:00	00:03:00	00:01:00	00:03:00	00:01:00	00:01:00	00:01:00	00:07:00	00:03:00	00:03:00	00:03:00	00:00:30	00:03:00	00:03:00		00:04:00	
		EVENT START TIME HR:MN:SC	152:52:00	152:54:00	152:57:00	153:02:00	153:05:00	153:06:00	153:09:00	153:10:00	153:11:00	153:12:00	153,16,00	153:19:00	153:22:00	153:25:00	153:25:30	153:25:30		153:28:30	
		MISSION Event No.	81	200	201	202	203	70Z	205	506	201	800	000	210		212	213	214	;	215	

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Mission Event No.	Event start Time HR:MN:SC	EVENT DURATION HR:MN:SC		MISSION PHASES AND EVENTS
216	153:28:30	00:00:00		COMMAND TUG TO PREFERRED DOCKING ATTITUDE (ORBITER)
217	153:29:00	00:03:00		MANEUVER TUG TO PREFERRED DOCKING ATTITUDE
218	153:28:30	00:07:00		VISUALLY INSPECT TUG (& PL) FOR DOCKING READINESS (ORBITER)
219	153:32:30	00:90:00		VERIFY ALL TUG SUBSYSTEMS (EXCEPT APS) SAFE FOR DOCKING (ORBITER/TUG)
220	153:32:30	00:90:00	:	MANEUVER TO FINAL DOCKING STATION (ORBITER)
221	153:38:30	00:15:00		ATTACH MANIPULATOR TO TUG (ORBITER)
222	153:53:30	00:03:00		VERIFY PHYSICAL ATTACHMENT INTEGRITY (ORBITER)
223	153:55:30	00:00:30		Inhibit tug aps jet firings (orbiter/tug)
<sub>422</sub> 5	153:55:30	00:00:30		COMMAND TUG RETRACTION/STOWAGE OF APPENDAGES (ORBITER)
225	153:56:00	00:00:00		RETRACT/STOW TUG APPENDAGES
526	154:00:00	00:50:00		COMMAND PASSIVATION OF TUG SUBSYSTEMS (ORBITER)
227	154:00:00	00:10:00	,	VENT & DUMP TUG FLUIDS
. 822	154:00:00	00:50:00		PASSIVATE TUG SUBSYSTEMS
229	154:20:00	00:02:00		VERIFY TUG/PL SUBSYSTEMS SAFE FOR RETRACTION (ORBITER)
230	154:25:00	00:10:00		RETRACT TUG TO CARGO BAY (ORBITER)
231	154:35:00	00:02:00		MATE/LATCH TUG/PL TO ORBITER BASE RING. VERIFY ATTACHMENT (ORBITER)
232	154:40:00	00:01:00		CONNECT ELECTRICAL UMBILICAL (ORBITER)
233	154:41:00	00:03:00		RELEASE, STOW/DEACTIVATE MANIPULATOR (ORBITER)

Sheet 6 EVENT DURATION HR:MN:SC Event Start Time HR: MH:SC

MISSION EVENT NO.

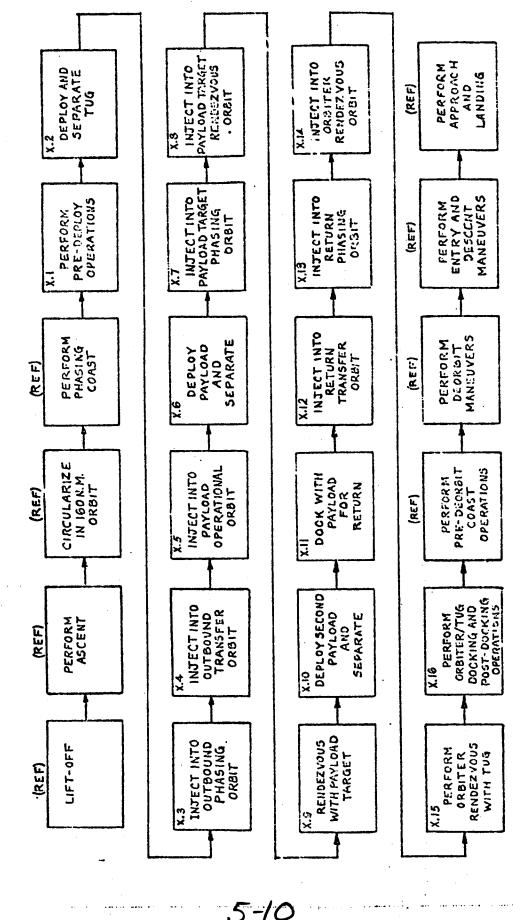
MISSION PHASES AND EVENTS

	ROTATE TUG INTO CARGO BAY, COMMECT VENT LINES (ORBITER)	SAFE TUG/PL FOR RETURN TO EARTH. INERT TANKS (ORBITER/TUG/PAYLOAD)	CONFIGURE CARGO BAY FOR ORBITER ENTRY (ORBITER)	CONFIGURE TUG SUBSYSTEMS FOR DEORBIT & ENTRY (ORBITER/TUG)	· PERFORM PRE-DEORBIT COAST OPERATIONS (ORBITER)	Perform deorbit maneuvers (orbiter)	PERFORM ENTRY & DESCENT MANEUVERS (ORBITER)	PERFORM APPROACH & LANDING
	00:02:00	00:08:00	00:90:00	00:03:00	12:00:00	00:00:00	00:42:00	00:00:00
	154:44:00	154:49:00	154:57:00	155:03:00	155:06:00	167:06:00	167:11:00	167:53:00
•	234	235	236	237				



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### FIRST LEVEL FUNCTIONS

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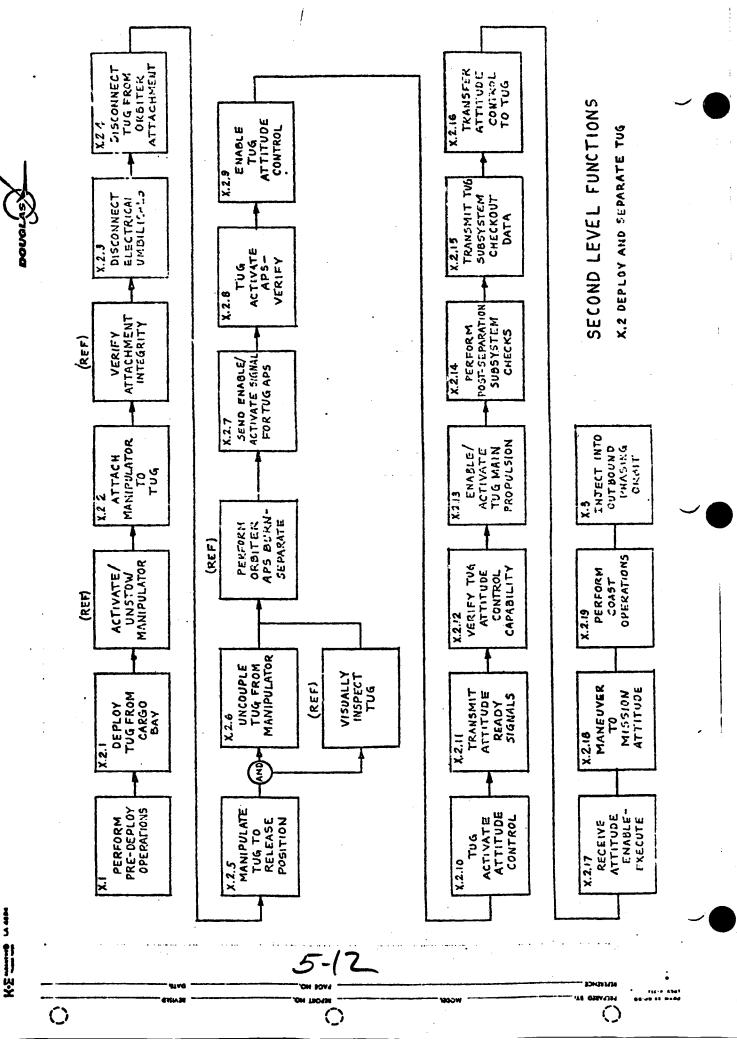
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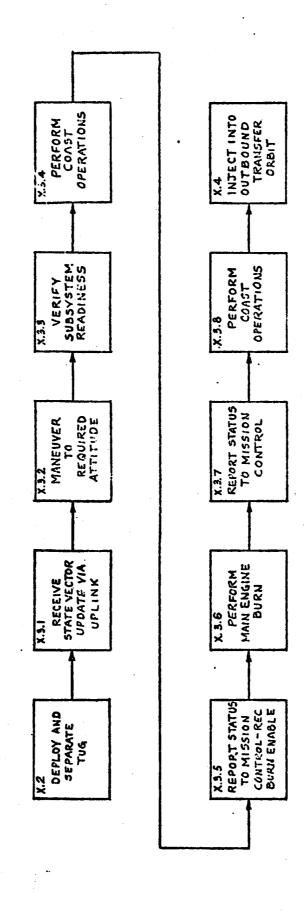
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SECOND LEVEL FUNCTIONS

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X.I PERFORM PRE-DEPLOY OPERATIONS





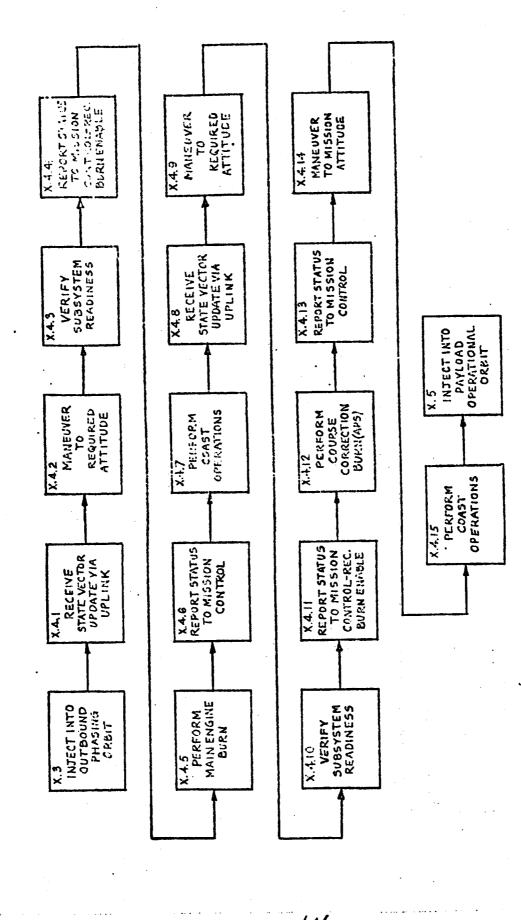
SECOND LEVEL FUNCTIONS

X.3 INTECT INTO OUTBOUND PHASING ORBIT

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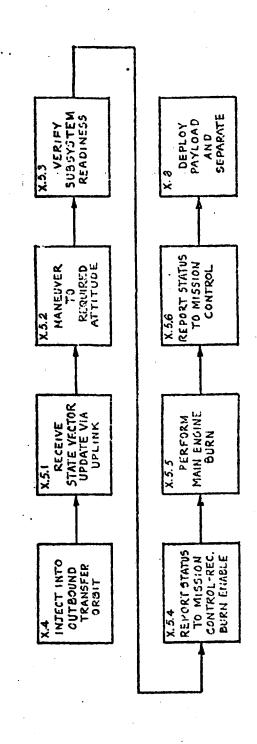


SECOND LEVEL FUNCTIONS

X.4 INJECT INTO CUTBOUND TRANSFER ORBIT

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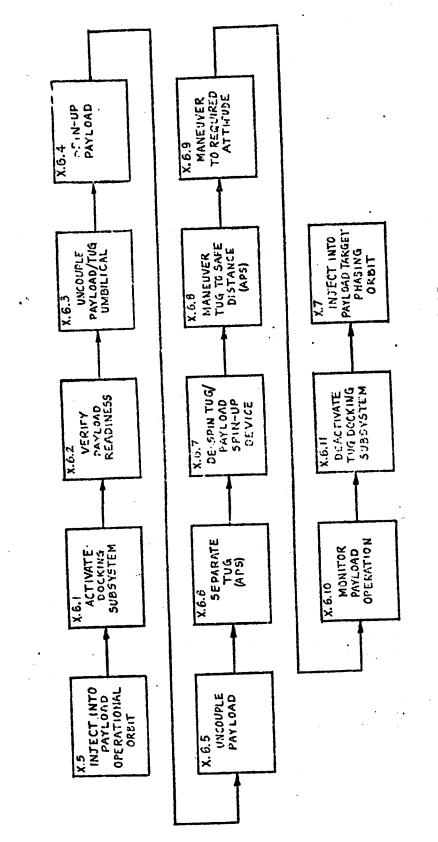


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### SECOND LEVEL FUNCTIONS

X.S INJECT INTO PAYLOAD OPERATIONAL ORBIT

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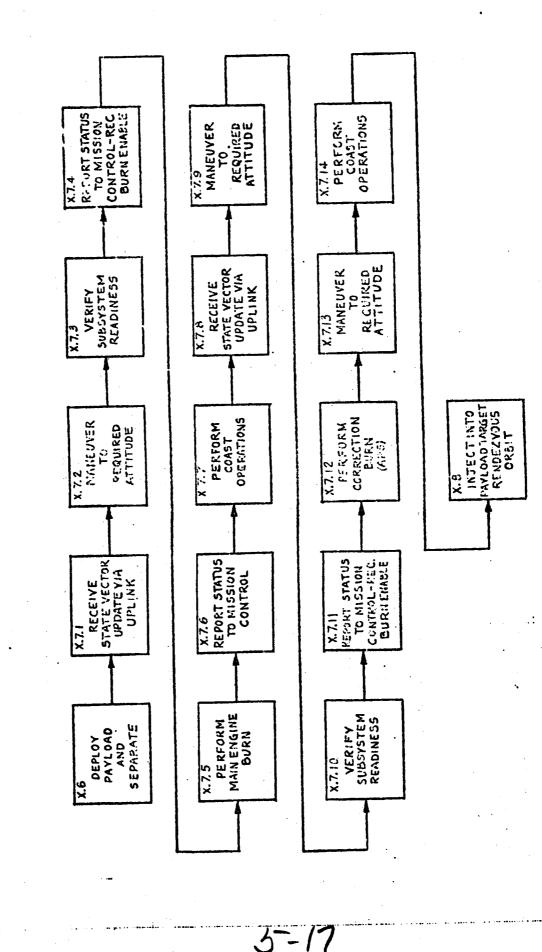
SECOND LEVEL FUNCTIONS

X.6 DEPLOY PAYLOAD AND SEPARATE

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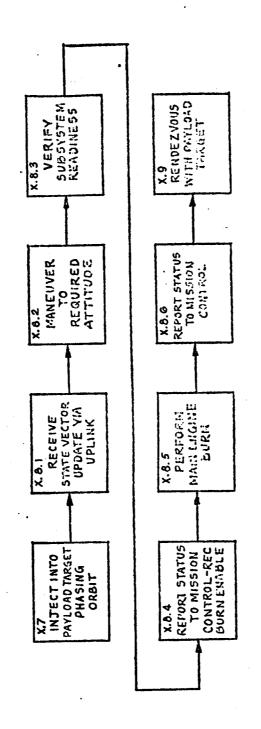
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SECOND LEVEL FUNCTIONS

X,7 INJECT INTO PAYLOAD TARGET PHASING ORBIT



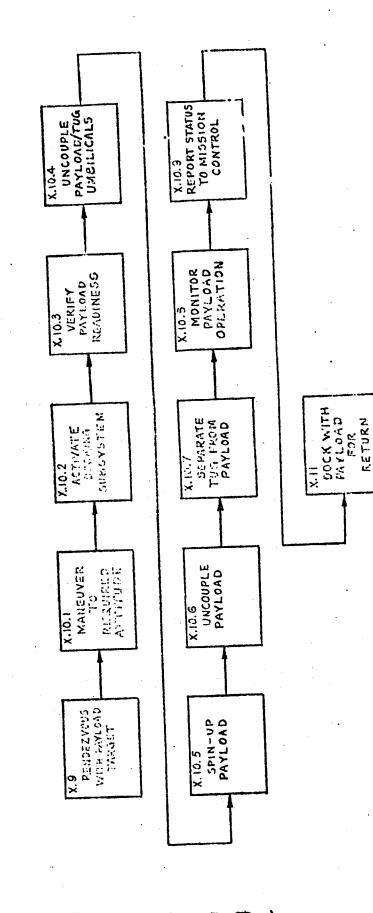
X.8 INJECT INTO PAYLOAD TARGET RENDEZVOUS ORBIT

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X.9 RENDEZVOUS WITH PAYLOAD TARGET SECOND LEVEL FUNCTIONS

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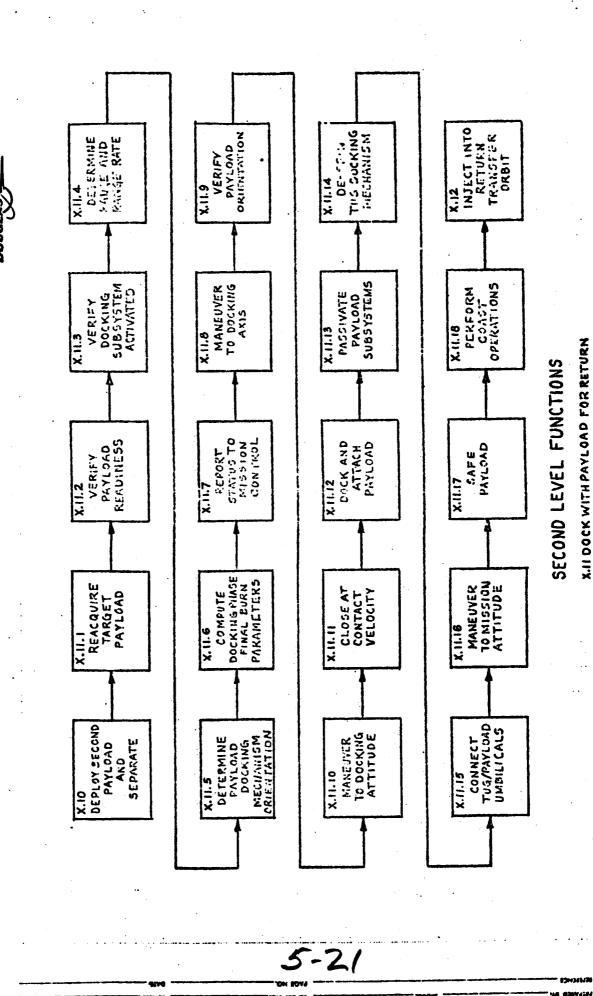




SECOND LEVEL FUNCTIONS

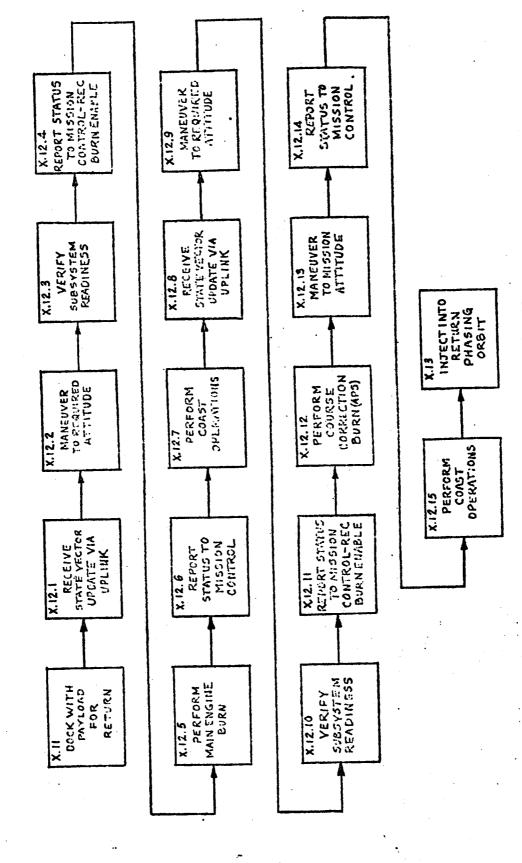
X.10 DEPLOY SECCILU PAYLOAD AND SEPARATE

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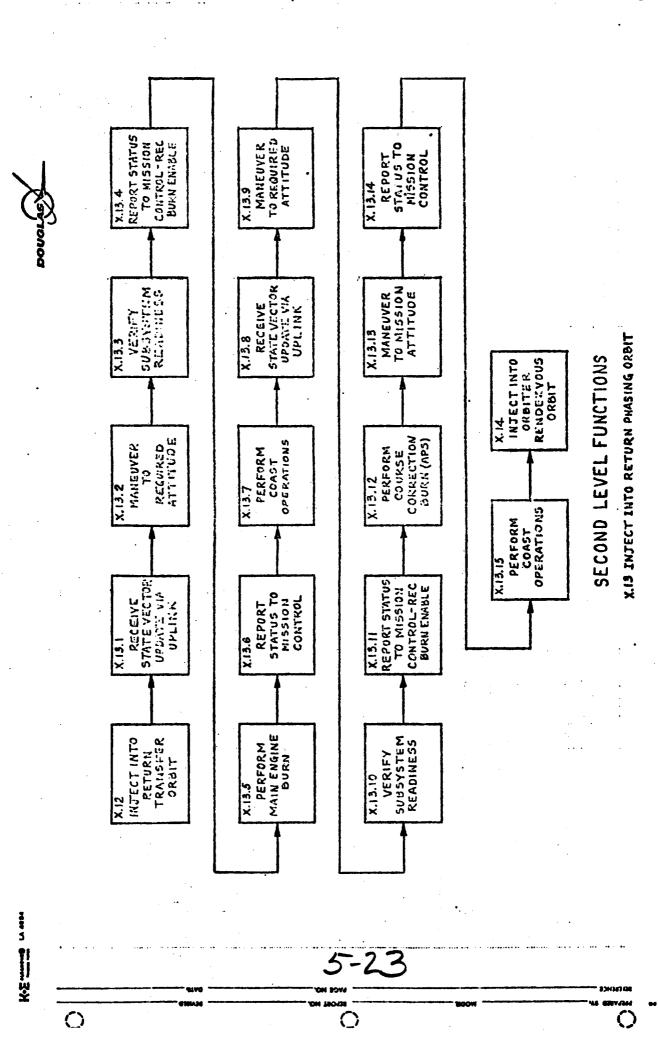




SECOND LEVEL FUNCTIONS

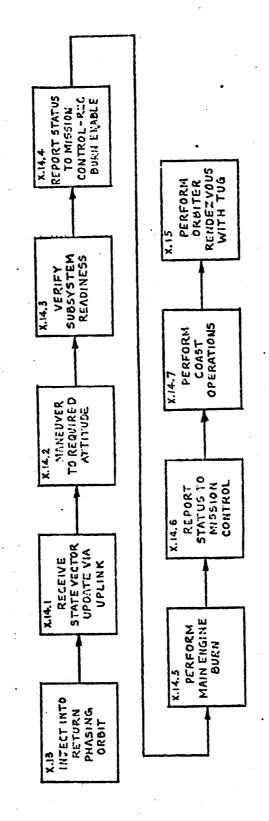
X.12 INJECT INTO RETURN TRANSFER ORBIT

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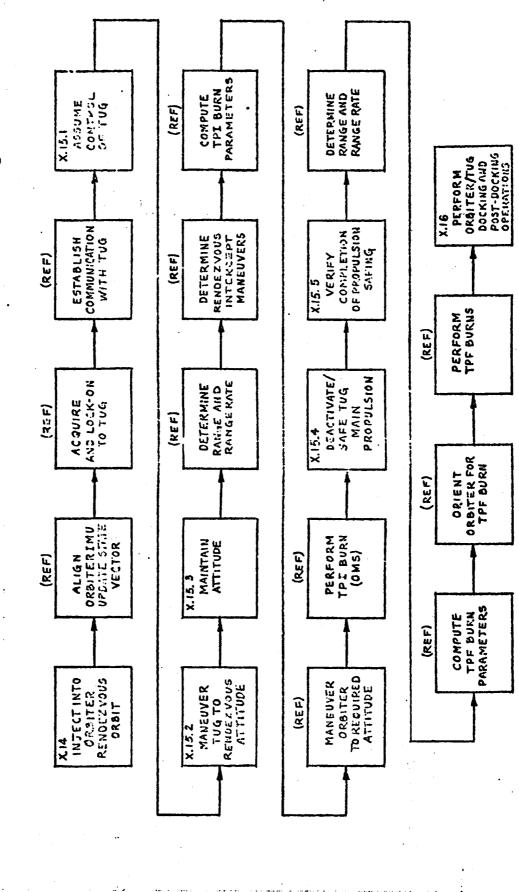
#### SECOND LEVEL FUNCTIONS

X.14 INJECT INTO ORBITER RENDEZVOUS ORBIT

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X.15 PERFORM DRBITER RENDEZ VOUS WITH TUG

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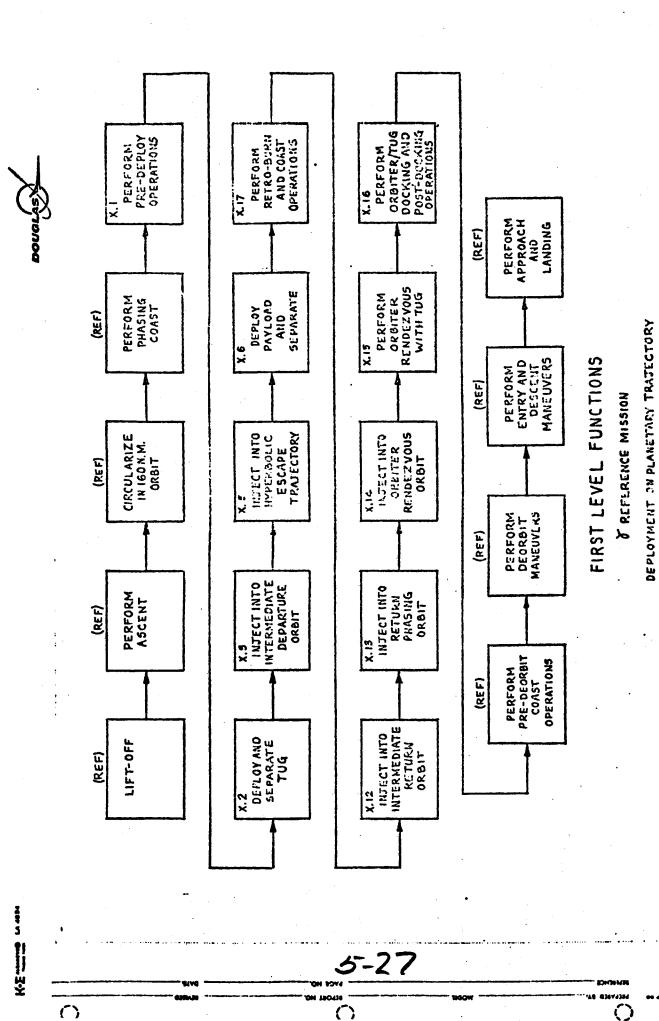
SECOND LEVEL FUNCTIONS

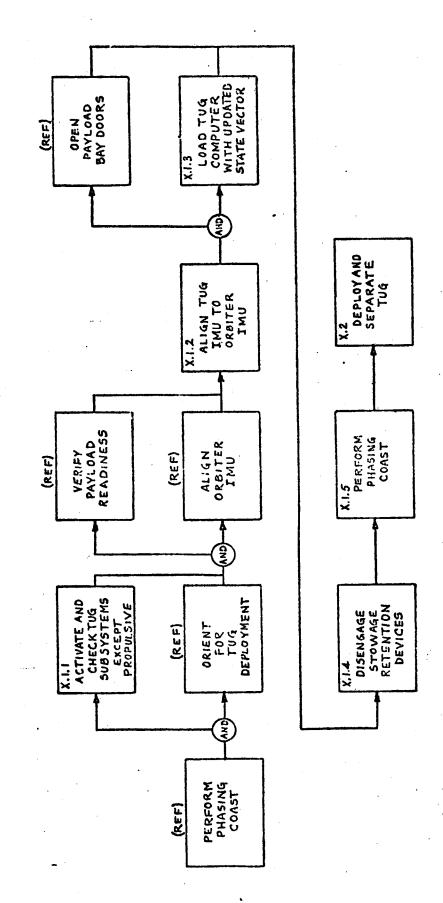
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SECOND LEVEL FUNCTIONS X.16 PERFORM ORBITER/TUG DOCKING AND POST-DOCKING OPERATIONS





K.I PERFORM PRE-DEPLOY OPERATIONS

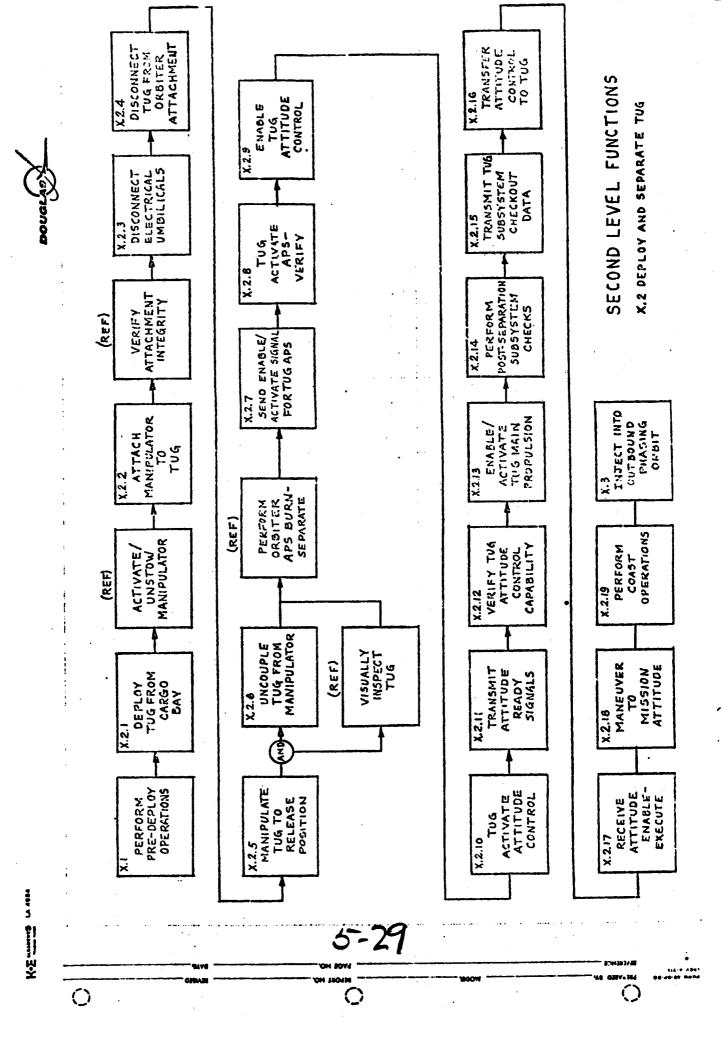
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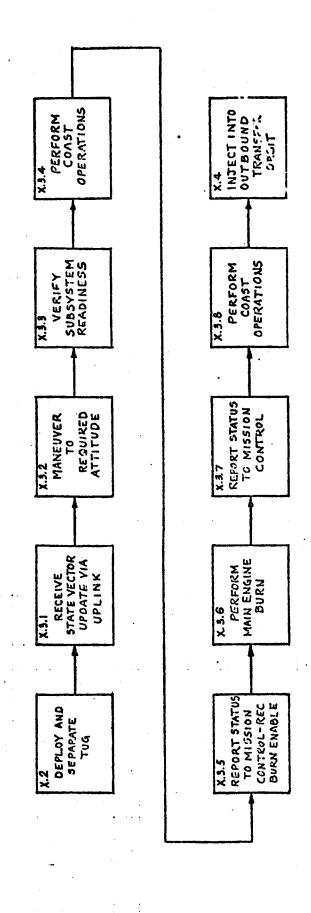
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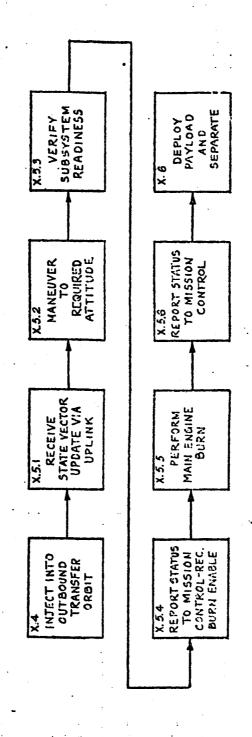




X.3 INJECT INTO OUTBOUND PHASING ORBIT

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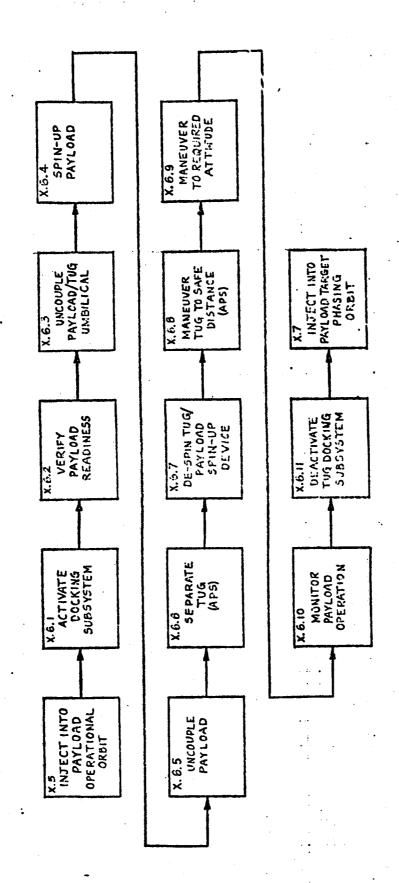


X.5 INJECT INTO PAYLOAD OPERATIONAL DRBIT

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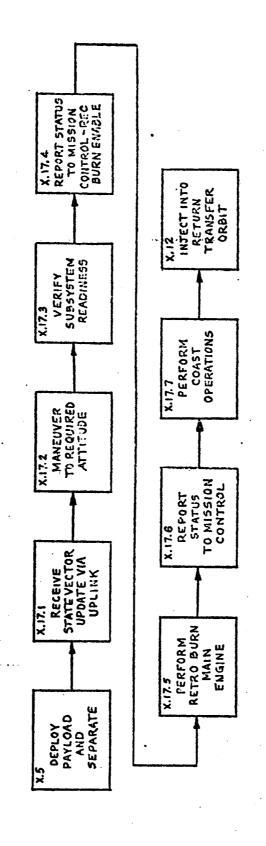


# X.6 DEPLOY PAYLOAD AND SEPARATE

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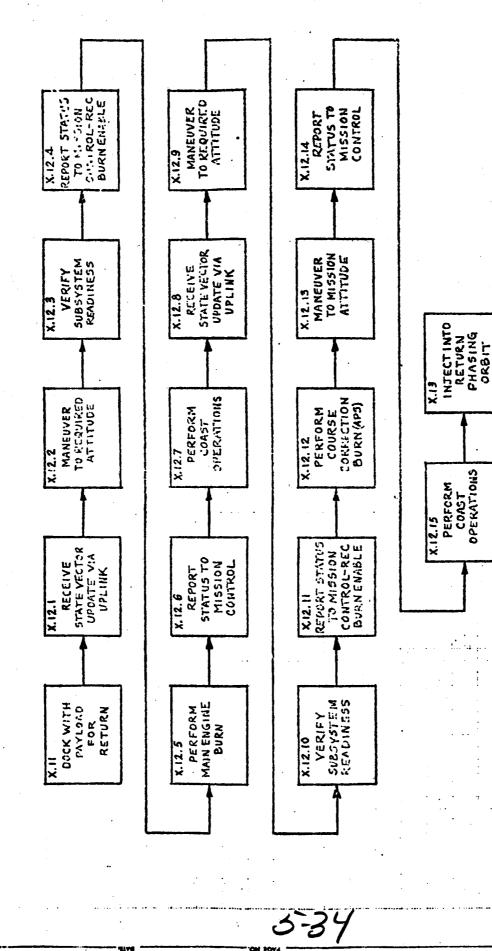
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X.17 PERFORM RETRO-BURN AND COAST OPERATIONS

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OPERATIONS

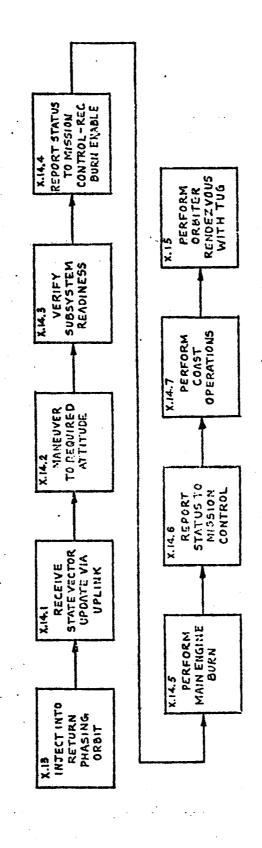
K.12 INJECT INTO RETURN TRANSFER ORSIT

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X.13 INJECT INTO RETURN PHASING ORBIT





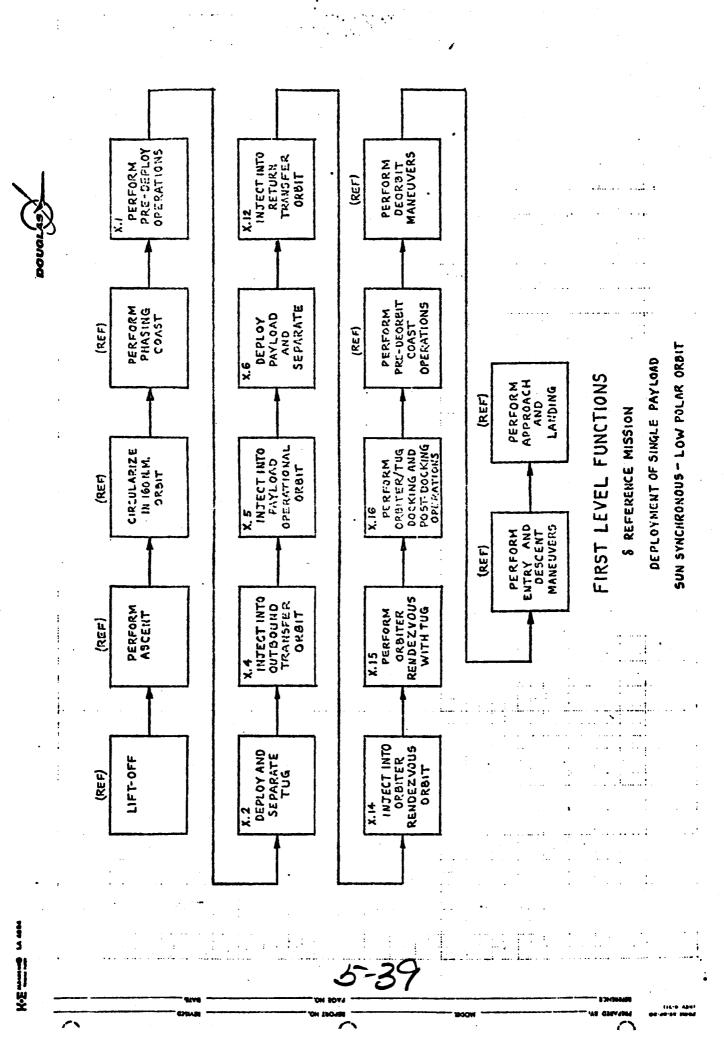
X,14 INJECT INTO ORBITER RENDEZVOUS ORBIT

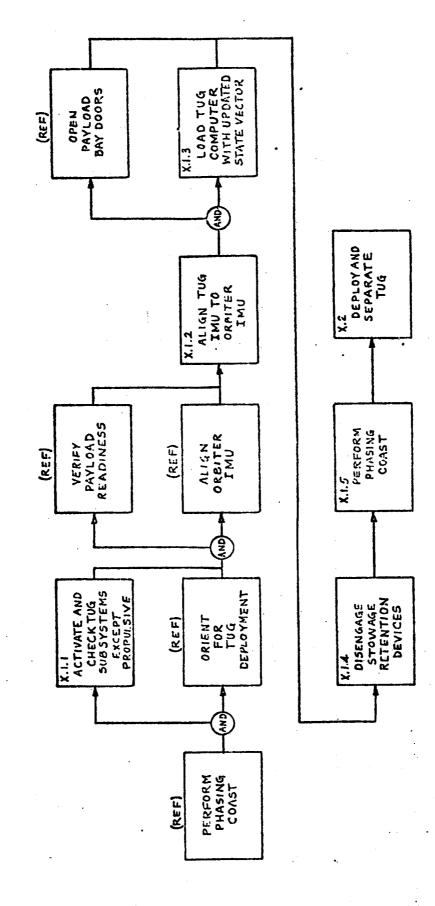
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#### X.16 PERFORM ORBITER/TUG DOCKING AND POST-DOCKING OPERATIONS SECOND LEVEL FUNCTIONS

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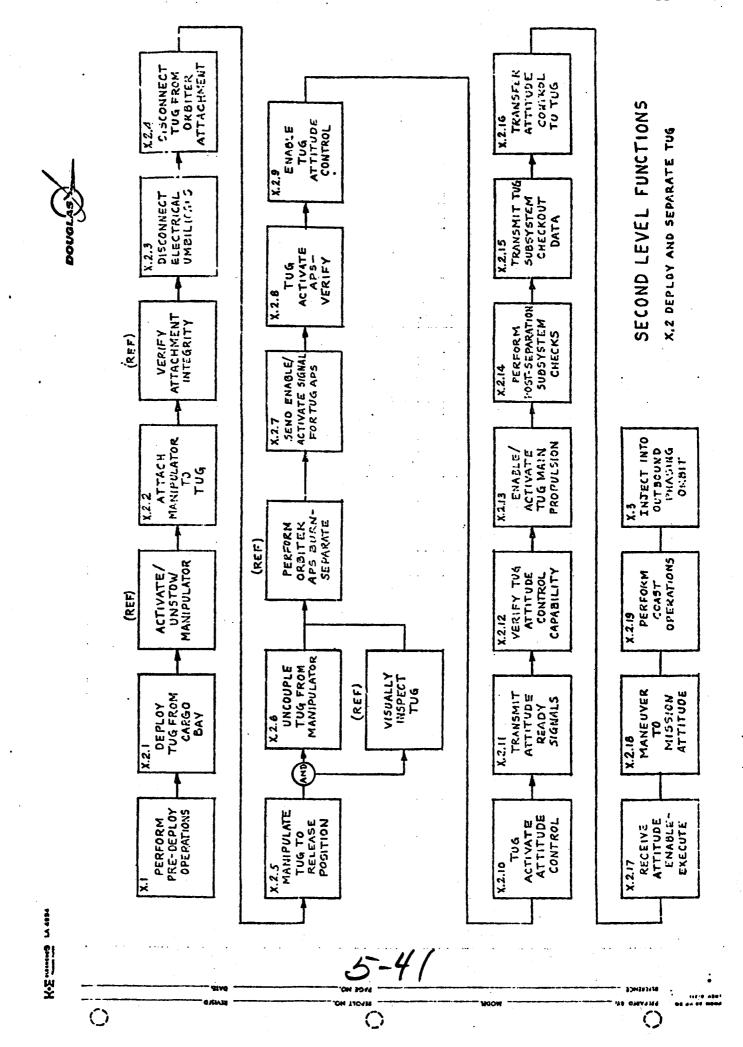




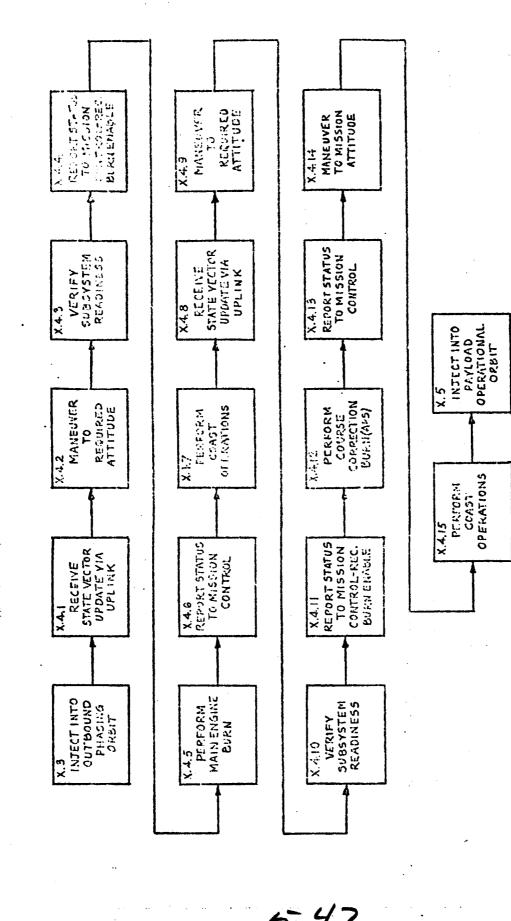
SECOND LEVEL FUNCTIONS

X.I PERFORM PRE-DEPLOY OPERATIONS

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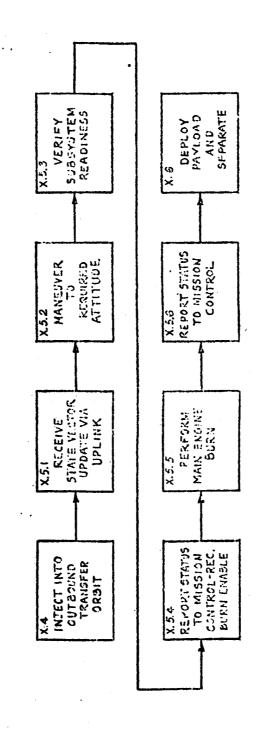


X.4 INJECT INTO OUTBOUND TRANSFUR ORBIT

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X.S INJECT INTO PAYLOAD OPERATIONAL ORBIT

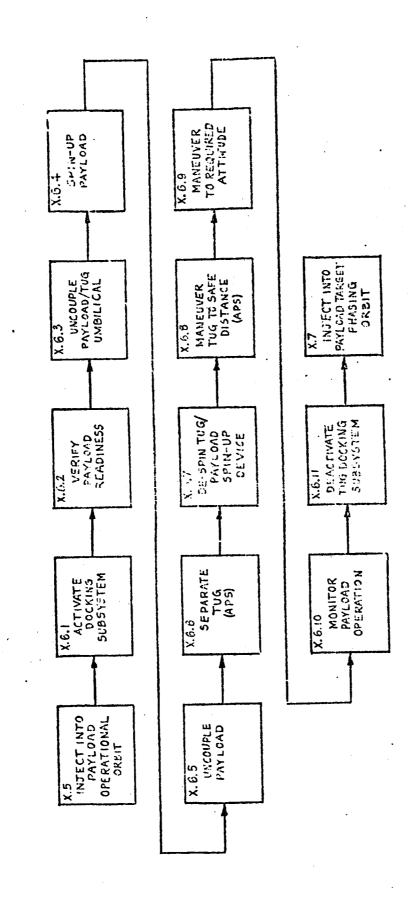
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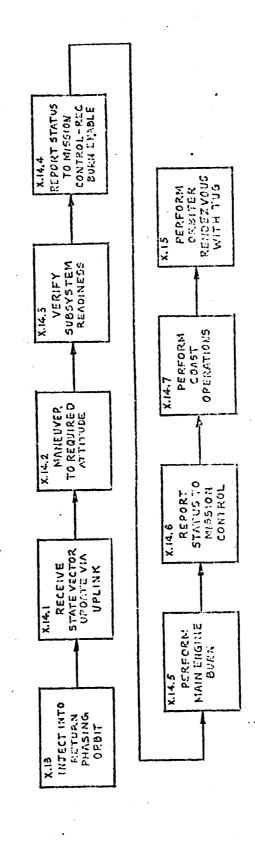
# X.6 DEPLOY PAYLOAD AND SEPARATE

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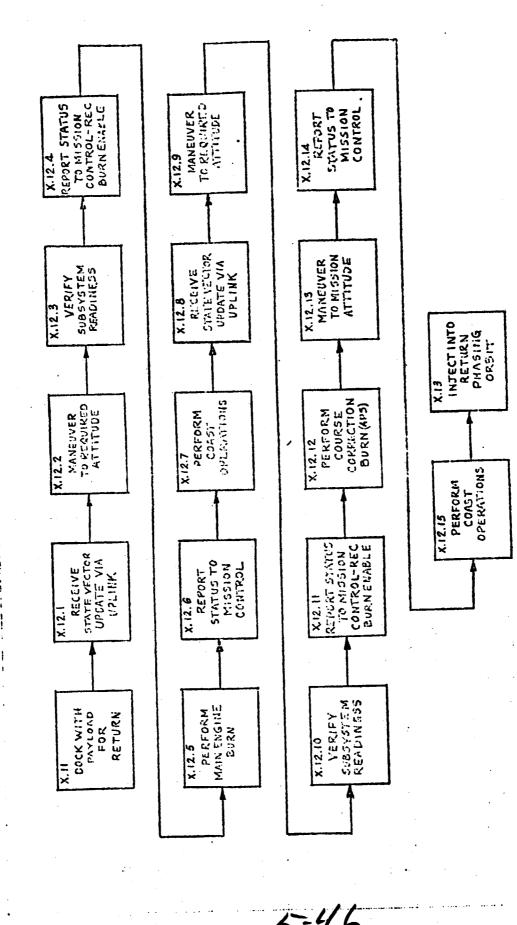
SECOND LEVEL FUNCTIONS

X.14 INJECT INTO ORBITER RENDEZVOUS ORBIT

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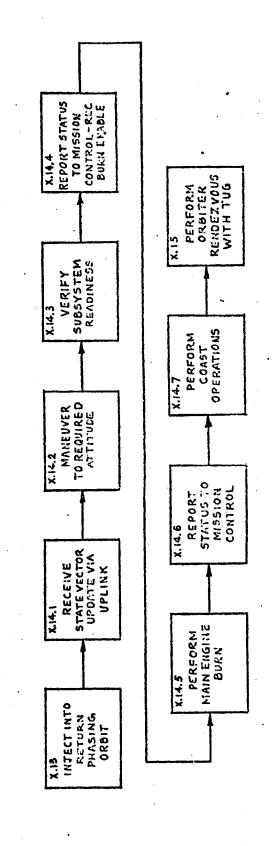


X.12 INJECT INTO RETURN TRANSFER ORBIT

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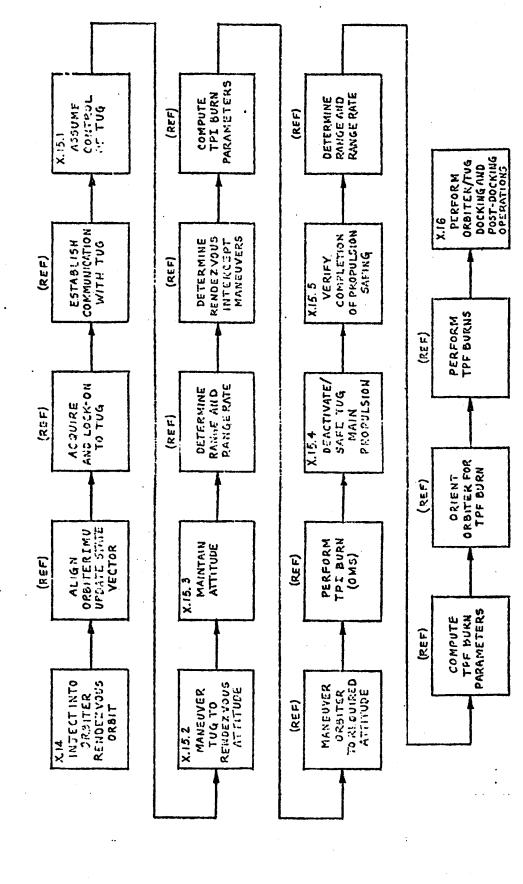
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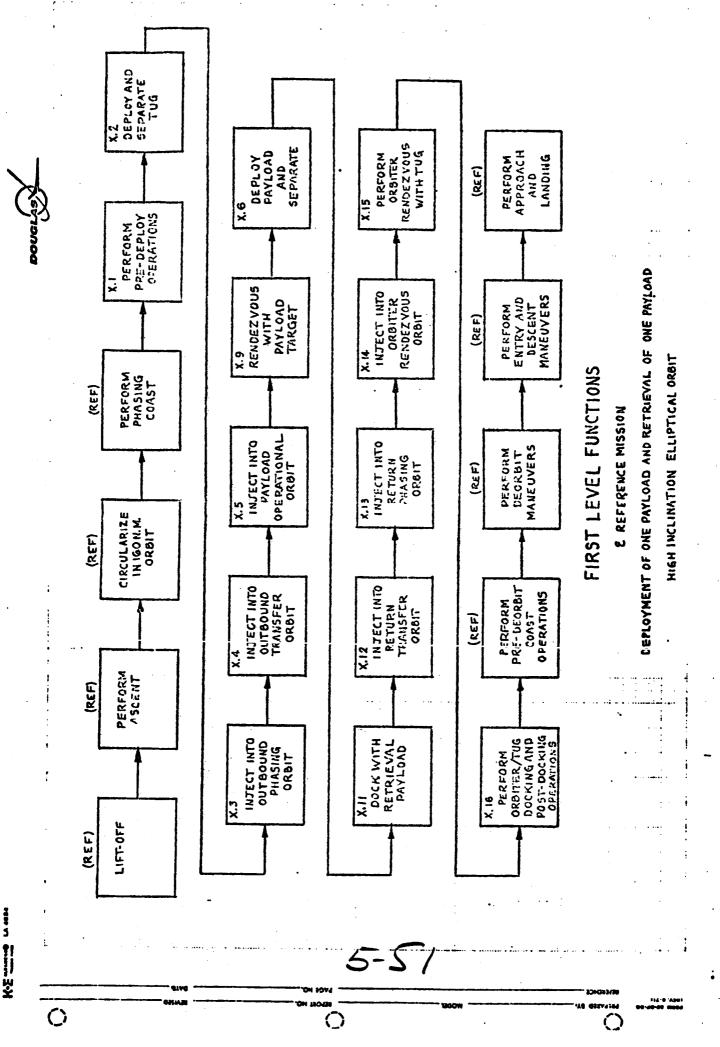
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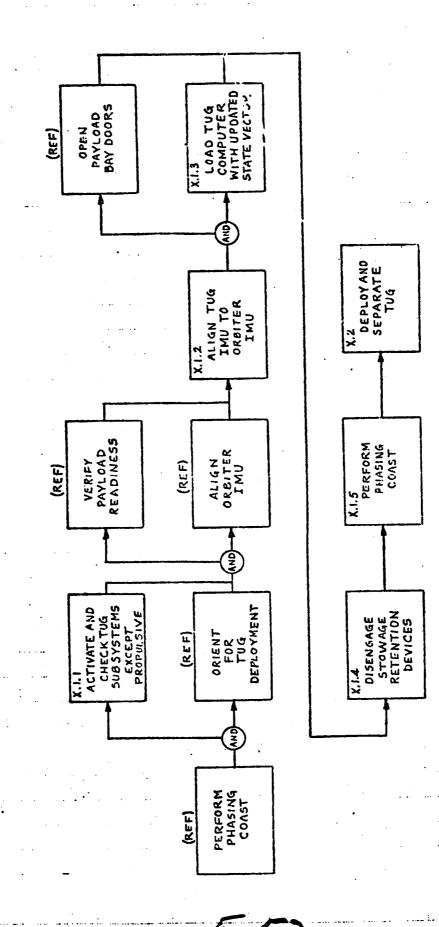
X.16 PERFORM ORBITER/TUG DOCKING AND POST-DOCKING OPERATIONS

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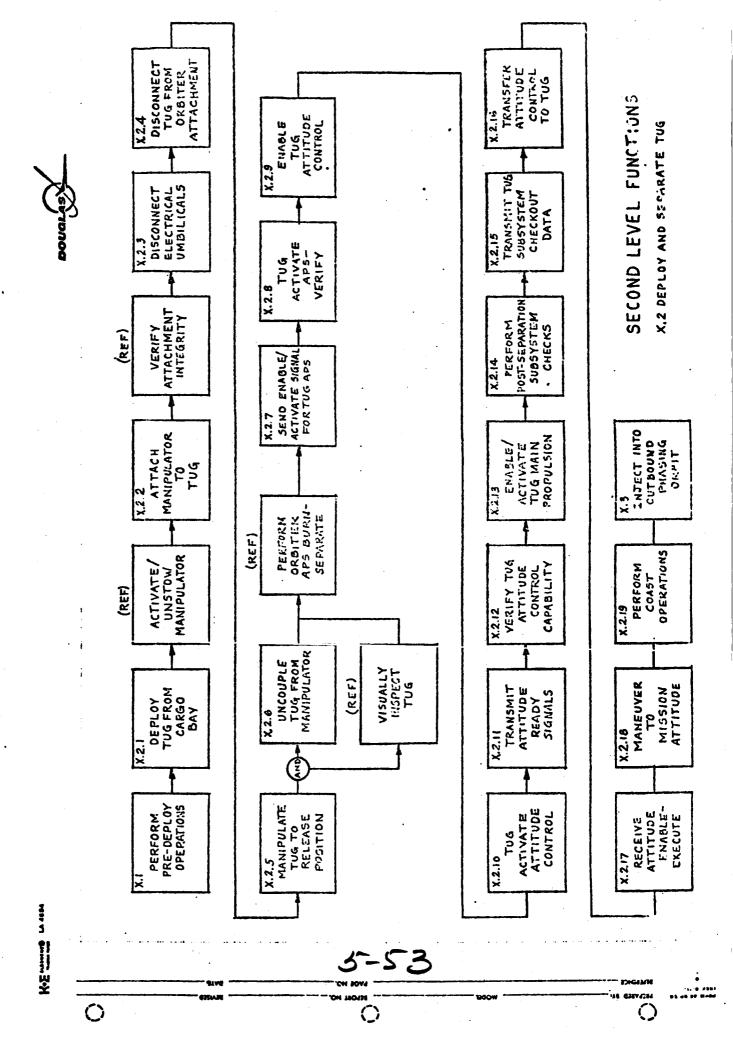


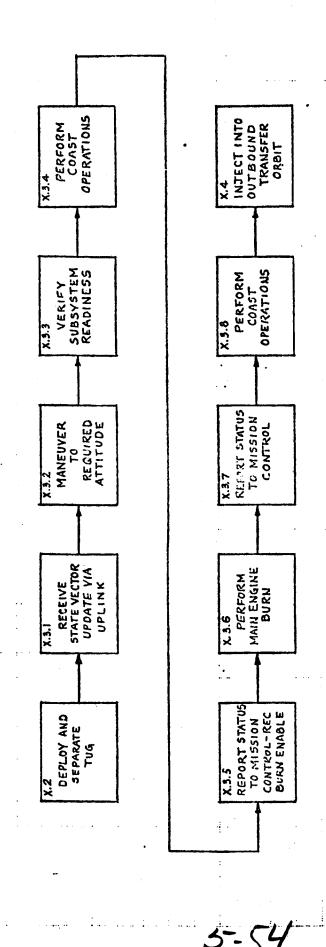


K.I PERFORM PRE-DEPLOY OPERATIONS

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X.3 INJECT INTO OUTBOUND PHASING ORBIT

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SECOND LEVEL FUNCTIONS

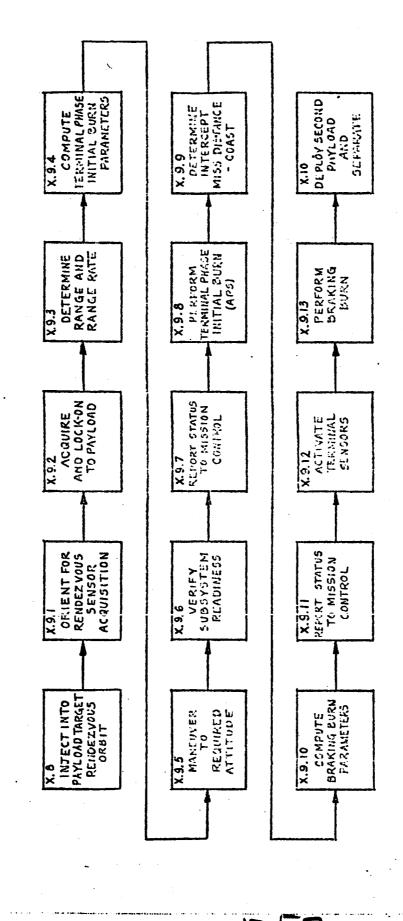
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X.5 INJECT INTO PAYLOAD OPERATIONAL ORBIT

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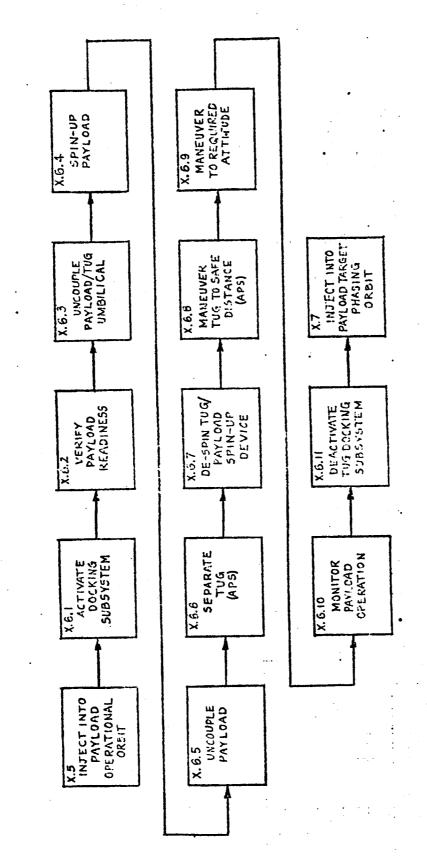
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X.9 RENDEZVOUS WITH PAYLOAD TARGET

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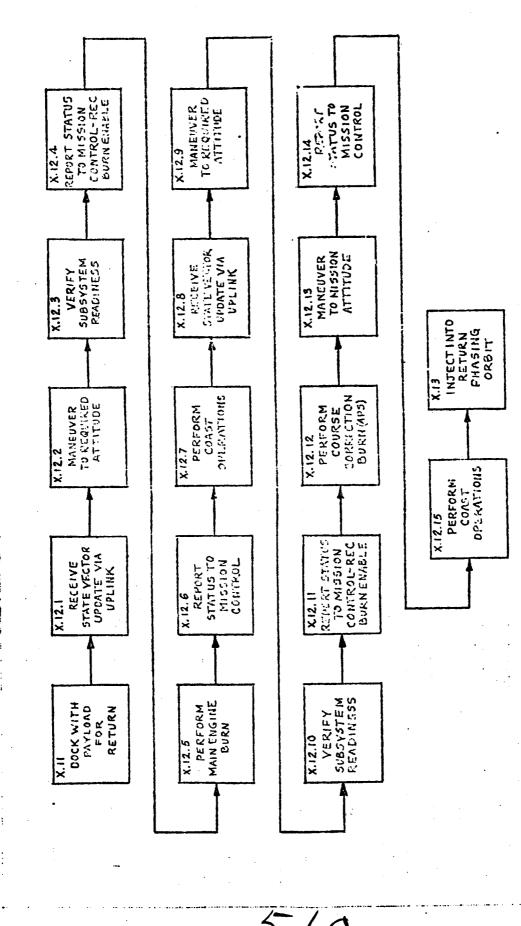
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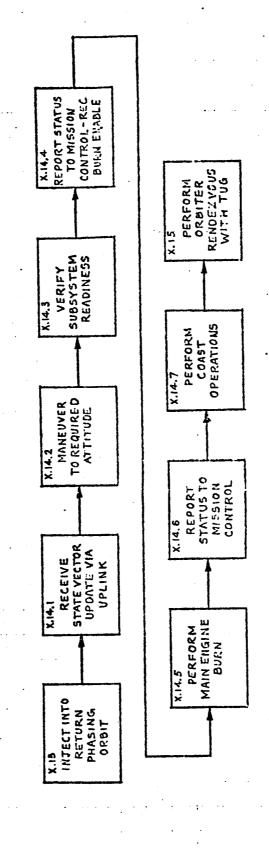
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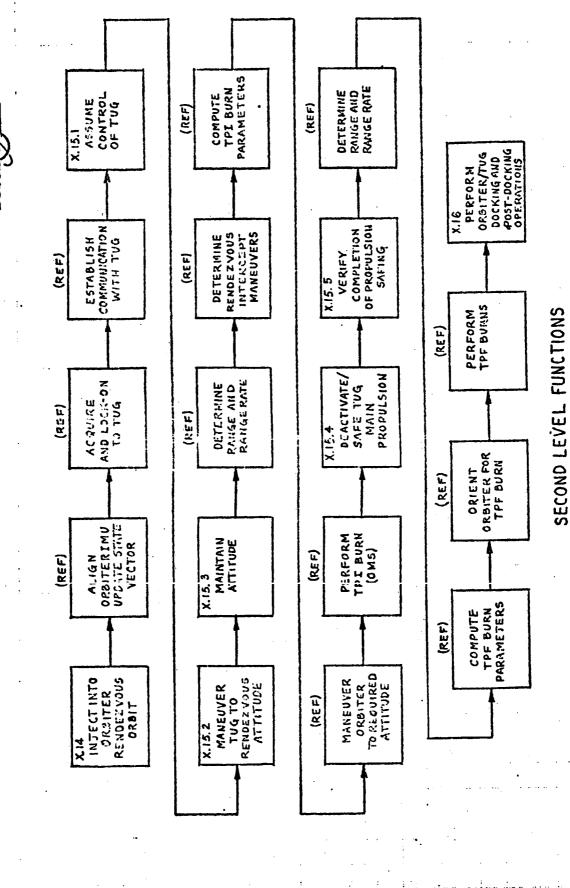
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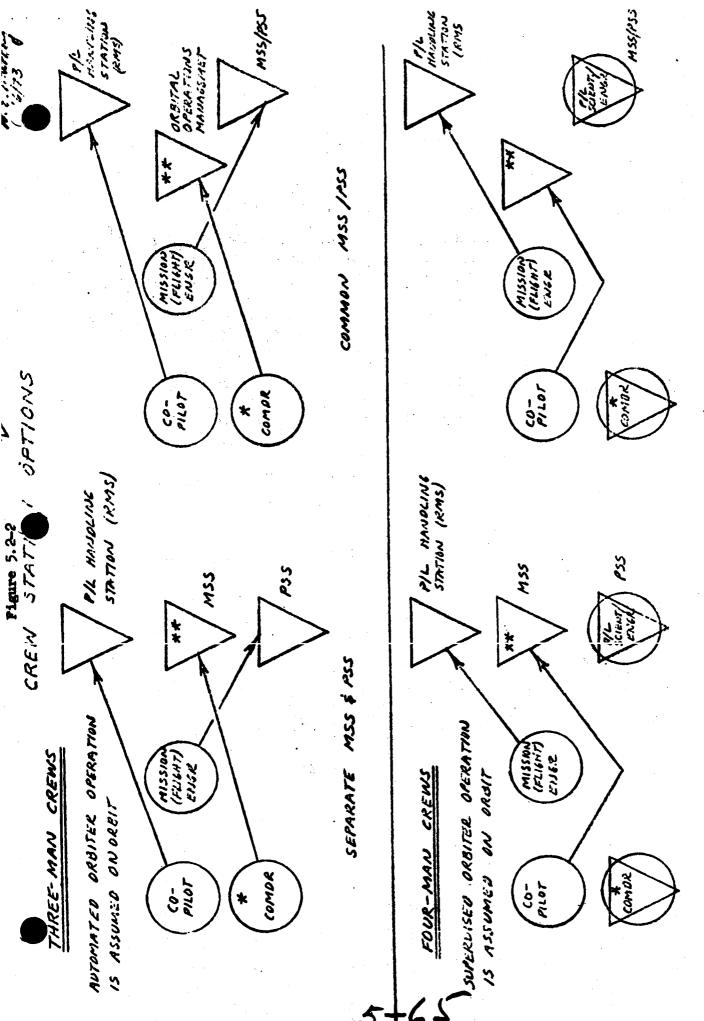


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K.IS PERFORM ORBITER RENDEZVOUS WITH TUG

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## One-Man Crew

(Totally Impractical)

<u>Two-Man Crew</u> (Difficult to impossible without highly automated systems)

If Autopilot operation of Orbiter is provided:

- Provide Orbiter C&W panel at mission specialist station
- Commander can operate mission specialist station
- Copilot can operate payload handling (RMS) station
- Payload monitoring, orbital readiness testing (health checks)
   are assumed to be Tug autonomous or performed by remote monitoring
   from the ground
- This mode is very demanding and may not be compatible with an unsophisticated payload with less autonomy incorporated for selfactivation and management

## Three-Man Crew (Practical minimum crew)

Similar to two-man crew in many respects.

- Autopilot operation of Orbiter is assumed
- Orbiter C&W panel is provided at MSS
- Commander provides overall supervision of all orbiter, Tug, and payload C&W monitoring, safety activities, and other operations; including communications with the ground and procedural document check off.
- Copilot operates payload handling (RMS) station as directed and maintains visual contact with the payload bay and contained hardware.
- Mission engineer/scientist operates combined MSS/PSS, including manual activation, monitoring and payload-related ground communications.
- Commander is available as backup to assist either of the other two crewmen (who are essentially immobilized by their duties). He can also respond to an orbiter emergency or caution signal without interfering with a possibly critical phase of payload deployment or retrieval.

## Other Factors

- Orbiter station provisions for other mission models will influence Tug missions because hardware/software will:
  - 1. Be available anyway as required for other missions.
  - 2. Shape the standard operating techniques of the crew.
  - 3. Influence the division of duties between stations via physical separation of equipment.
- Fourth man can be derived from other missions (Sortielab)
- Prelaunch operations by the crew when both Orbiter and Tug/payload
   activities are involved (same for reentry) will be time-constraining.
- Complexity and/or extensive manual support by the crew of some payloads (now in mission model or potential for future addition). Mission flexibility for future added missions and for mission extension may dictate other than a minimum crew capability for the Orbiter.
- Orbital readiness testing of payloads is a key driver, particularly with continuous activity but intermittent ground station passes. Calibration of complex channels and de-gassing time lost for high voltage equipment have been identified, and real-time data verification or analysis will require crew time and skills. While these could be passed to the ground, acted upon and control directives be sent back up; the times over truth sites, time to communicate, time to command new data acquisition and time before again passing over truth sites will impose operational complexities and constraints. This suggests more available crew time and skills.
- Many safety-related activities (passivation, stabilization, purging, de-activation) for Tug and payloads; plus Tug maneuvering, Orbiter maneuvering, RMS operation, Tug support hardware operation, and Tug monitoring functions occur during Tug/payload retrieval.
- SOAR II-S study mid-term (July 1973) conclusion: "Insufficient time exists for all payload subsystems to be checked out at MSS. Therefore it is recommended that Tug and Orbiter performance and checkout be performed at the MSS and that spacecraft systems as well as experiments be handled by the PSS."

• Provides better management during launch, abort, and return flight when both commander and copilot are fully occupied with Orbiter flight duties

Four-Man Crew (Provides ample manpower with less operational constraints)

- Manual supervision of the Orbiter by the commander is assumed.
- Copilot assumes active supervision of payload operations with functions similar to those of the commander described for a three-man crew. He may operate a separate MSS.
- Mission engineer operates payload handling (RMS) station
- Payload scientist/engineer operates a common MSS/PSS, or he operates the separate PSS.
- Provides more skills and better timeline potential for off-duty time.

capability, and total crew-skills will be available from a four-man crew. The four-man crew also allows rest or sleep periods for extended and combination missions; and it allows for commonality of equipment, training, and operational procedures between short Tug deployment or retrieval missions and the seven-day Sortie Lab missions, for example.

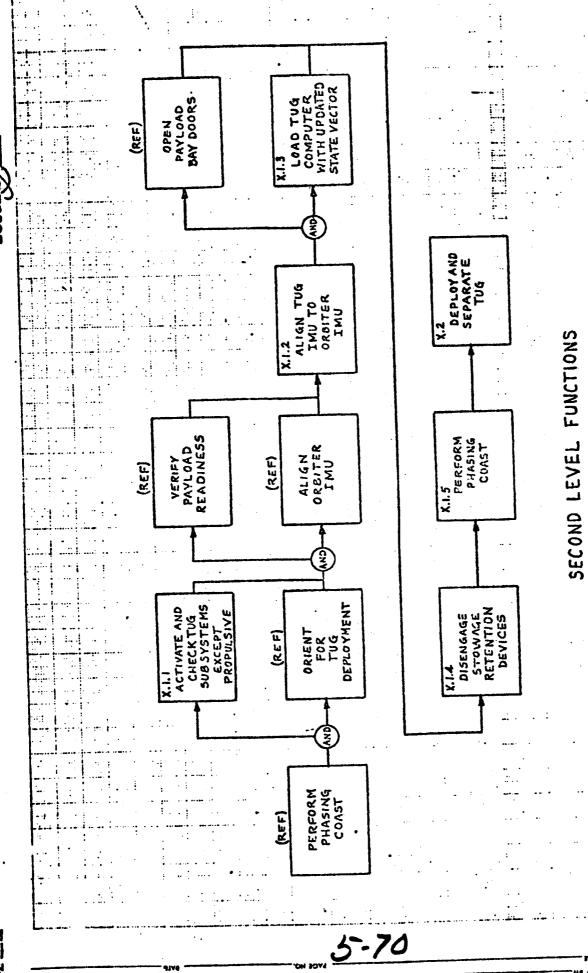
Additional insight for crew functions is provided by the Second-Level Function charts, Figures 5.2-3 through 5.2-6. Additional information, functional flow charts, and operational concepts are provided in Section 6.2.2 for the complete missions.

## 5.3 Computer Requirements

The Tug subsystems are monitored, activated, and checked out through the Tug Data Management System as described in Volume 5, Section 5.4.2.3. The avionics interfaces include a Tug-unique panel section on the Mission Specialist Station (MSS) panel. These dedicated elements provide a capability to access the Tug subsystems data and to convert it for input to the Orbiter computer and/or the payload computer (these may be combined physically or functionally). The Tug data may be displayed directly on the Tug-unique Control and Display panel, or it may be processed by the Analog/Digital Converter/Multiplexer and transferred to the Shuttle Payload Computer for display on the Orbiter Performance Monitor Panel at the MSS.

Control functions which are necessary to correct for caution and warning signals and conditions are provided on the Tug unique Control and Display panel at the MSS. These may operate either directly upon the affected Tug subsystem circuitry or may utilize Shuttle Payload computer or Tug internal computer capabilities. The preference will be to utilize the Tug computer for all computer services which are available to autonomously manage the same function after Tug deployment.

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X.I PERFORM PRE-DEPLOY OPERATIONS

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Figure 5.

X.15 PERFORM ORBITER RENDEZVOUS WITH TUG SECOND LEVEL FUNCTIONS

Figure 5.2-5

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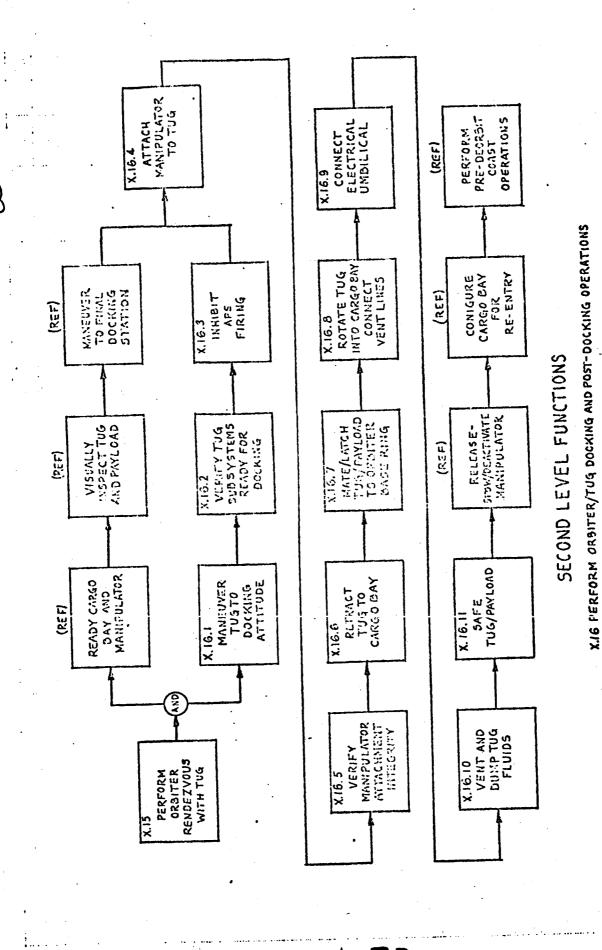
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The specific bit rate requirements are shown in Volume 5. Section 5.4.2.3 for the Shuttle/Tug interface as follows:

Orbi	ter to Tug	Tug to Orbiter
NASA Communications	2,000 BPS (Data and Time Multiplex Commands)	25,000 BPS (Tug/Payload Status Data and Command Verfication)
DOD Communications	2,000 BPS (Secure Command Data)	16,000 BPS (Tug/Payload Status Data and Command Verification)
	16,000 BPS (Program Modifying Data)	256,000 BPS (Payload Secure Data)
		FM/FM IRIG Payload Analog Instrumentation Data

### 6.0 ABORT ANALYSIS

An abort analysis was conducted to assess the merits, liabilities and relative impacts of (1) landing with full LO<sub>2</sub> and LH<sub>2</sub> tanks, (2) dumping LO<sub>2</sub> only, (3) dumping both LO<sub>2</sub> and LH<sub>2</sub> in sequence, and (4) dumping both LO<sub>2</sub> and LH<sub>2</sub> simultaneously. Abort from both suborbital (Mode III) and orbital (Mode IV, V and VI) were analyzed. These options are discussed in detail as part of the trade studies reported in Section 12.6, covering land full versus dumping options. The results of these analyses are reported in the abort analysis summary, Section 2.5.

The abort analysis discussed below includes:

- (6.1) a detailed sequence list and timeline of the events associated with cryogen dumping;
- (6.2) the Shuttle requirements to be satisfied during the dumping sequence;
- (6.3) the flight altitude and time of dumping events versus the dumping sequence and the cryogen load analysis for these events; and
- (6.4) a delta-V analysis for the impulse compensation necessary as the result of the propulsive dumping required to sustain propellant settling on an orbital abort, and an assessment of the potential delta-V gain available as the result of either early or late sumping during main engine operation.

## CRYOGEN HANDLING

	,	
CONDITION	TO <sup>5</sup>	TH <sup>5</sup>
Normal Mission		
Passivation:	o Keep residual LO <sub>2</sub>	o Flow residual LH <sub>2</sub>
(Before Tug capture)	o Vent above 18 psia	through engine down
		to 3 psia
Venting:	<del></del>	omes en beden Geschillermassierichen deuen z. Des Ermändermanniere Geschillerspreise zum .
(After Tug capture/	o Keep residual LO2	o Vent again to 3 psia
stowage)	o Vent above 18 psia	o Fill with ambient He to 26.3 psia
		o Vent down to 16+1 psia
		o Vent above 18 psia
gengin annaks ut assamblas (sp. 19 mill) mar de trabille am mendige am de mill se mendie am se en 2 mill - anna millionis, e un argement a section section and real estadation (e. adaption assamble).	aller e alle distribuis palembere vällständerserierikerte vär der e die ekser ferak värelde det diet Norvar desig värtlerde entre settigs derekter värtler dietagenar värtler kölnik och de all medisterierier et d	து நடிக்காதா காகுவக்குவும் முறு நாறு நாறையாகில் நடிது இண்டுமாகி படு படுக்கும். நடித்த தடத்தில் நடித்தில் நடித்தி அரசு என்ற என்ற நடித்திற்கு நடித்தில் நடித்தின்ற இண்டுக்கும்.
Aborted Mission	•	Nominal
Suborbital:	Dump LO <sub>2</sub> to 15 psia:	o Keep LH2 in tank
(Mode III)	(1) During engine firing,	o Vent above 18 psia
	20% minimum through 3" abort line	Alternative Study Options
	(2) After ET jettison, remainder through 3-inch abort line	o Dump sequentially after LO (CG con- straint) down to
•		110K ft through 4cm 5
	64. 64 <u>. 64. 64. 64. 64. 64. 64. 64. 64. 64. 64</u>	inch abort lines o Dump simult. thru 3-In.line
Orbital:	Dump LO, to 15 psia:	Preferred-Options 2 & 3F
(Mode IV,V,VI)	Primary Method: (1) During orbital flight, 100% through 2-inch	o Dump under vapor pressure to 15 psia
·	F/D port and tap to	o Keep remainder
	3-inch abort line.	o Vent above 18 psia
	Alternative (Backup) Method:	Preferred-Options 1 & 31
	(1) During orbital flight, ~ 40% through 3-inch	o Dump under vapor pressure to 3 psia
	abort line (2) During reentry glide,	o Fill with ambient He to 26.3 psia
	remainder through	o Vent down to 16±1 psia
	3-inch abort line	o Vent above 18 psia
		Alternative (Backup)
	6-2	o Keep LH <sub>2</sub> in tank
		o Vent above 18 psia

o Vent above 18 psia



# ABORT MODE ANALYSIS SUMMARY AND CONCLUSIONS

No dump; continue flight to Modes II or III abort period. Mode I

No dump; SRB thrust termination eliminated, SRB separation at 115 sec before dumping is permitted (No Mode II abort, as directed by COR instructions). Mode II

Start LOX dump at T+116 to T+251 sec; 310 to 280 sec are available before MECO-30, 704 to 649 sec after MEC0+30. Mode III

Adequate time is available from a 3-inch LOX dump line for Mode III abort.

Cryogen dump during engine operation is acceptable according to NASA study directives. 0

Dump LOX and/or LH2 when liquid/gas interface is relatively stabilized. 0

Simultaneous dumping is reported to be acceptable when all the following conditions prevail:

- LOX and LH2 outlets are separated by > 300 inches

- Atmospheric pressure > 0.1 psia

- Altitude is > 110,000 ft

Sufficient time exists above 110,000 ft in a Mode III abort for simultaneous LH2 dump with a 3-inch line, including dump time before and after MECO. 0

Sufficient time exists above 110,000 ft in a Mode III abort for sequential LH2 dump with a 4-inch line, including dump time before and after MECO. Insufficient time exists above 110,000 ft in a Mode III abort for LH2 dump in stable condition, after MECO 0

Sufficient time exists above 110,000 ft in a Mode III abort for LH2 dump in variable condition with a 5-inch line, after MECO.

Land full will cause an undesirable reduction of payload capability (-2,051 lb) 0

CONCLUSTONS:

(1) LO2 dump is recommended for suborbital abort.

(2) LO2 and LH2 dump is recommended for orbital abort.

## ABORT STUDY ASSESSMENT

× ≺	DUMP CRYOGENS
LO <sub>2</sub> ONLY 3 IN. LINE +806 +144 +144 +144 +164 +164 +181 -815 -178 -178	LO2 AND LH2
(LB)* +94 +340 (LB) -815 -178	3 IN. LINE 3.5 IN. & 5 IN. 3 IN. & 5 IN.
(LB)* +94 +340 (LB) -815 -178	+144 +177
LB) -815	+340 +1303 +1297
-815	
-2015	
-	-489938

## LAND FULL LAUNCH FULL,

SAFETY ASPECTS QUESTIONABLE

ACCOMMODATE CRASH LOAD FACTORS (ABORT AND CRASH LANDING ARE NOT CONCURRENT CANNOT

CONDITIONS FOR THIS STUDY)
LANDING CG OUTSIDE OF JSC 07700 PROFILE RANGE

## DUMP SYSTEMS

SUBORBITAL DUMP IN MODE III ABORT (T +116 SEC OR LATER)
SIFULTANEOUS LH2 DUMP AND LO2 DUMP DEPENDS ON TIME AVAILABLE ABOVE 110K FT
SEQUENTIAL DUMP IS PREFERRED WHEN TIME AVAILABLE, FOR SAFETY MARGIN
SIMULTANEOUS DUMP SAFETY DEPENDS ON ATMOSPHERE PRESSURE AND OUTLET PORT SEPARATION
PAYLOAD WEIGHT IMPACT & CG BENEFIT CONTRIBUTE TO LO2 DUMP PREFERENCE

LO, DUMP RECOMMENDATION:

## INCLUDES ANCILLARY EQUIPMENT

AWPL = - [AWTUG + 0.1 (AWORBITER)] FOR ROUND TRIP

ΔWPL = - [ΔWTUG x 2.5 + 0.38 (ΔWORBITER)] FOR DEPLOY TO GEOSYNCH ORBIT \*\*\*

## 6.1 Detailed Timeline of Events

There are several abort conditions to be time-lined. The major abort conditions are suborbital (Mode III) and orbital (Modes IV, V, and VI).

## Suborbital Abort

The selected suborbital abort mode is to dump LO<sub>2</sub> and to retain and land with LH<sub>2</sub>. Refer to the trade studies in Section 6.12.6 for option time-line descriptions for the other alternative options. The LO<sub>2</sub> is partially dumped (to 20% minimum and approximately 40% maximum) while the orbiter main engines are operating, in order to assure CG compatibility subsequent to External Tank (ET) jettison. The remaining LO<sub>2</sub> is dumped down to 15 psia during the glide return period. The time-line is shown in Table 5.6.1-1.

## Orbital Abort

The selected orbital abort technique (for Modes IV. V. or VI) provides settling thrust with the Orbiter OMS engines, then propulsively dump  $IO_2$  down to 15 psia through the 2-inch  $IO_2$  fill and drain line and the bypass valve(s) to the 3-inch  $IO_2$  abort dump line boat-tail exit port. When  $IO_2$  dump is completed. CG compatibility is assured, and the preferred propulsive  $LH_2$  dumping is accomplished through the 2-inch  $LH_2$  fill and drain line and the bypass valve(s) to the 2-inch  $LH_2$  abort dump line boat-tail exit port. A backup operational technique is to dump up to 40% of the  $IO_2$  through the 3-inch side abort dump port, then dump  $LH_2$  as above, and finally to dump the remaining  $IO_2$  after ET jettison and during the glide return. A second backup mode is to use either of the above  $IO_2$  dump modes and to retain the  $IH_2$  to landing.

Essentially the same timelines are used for Modes IV, V, and VI abort. A much longer time is available for dumping than for Mode III suborbital abort.

Modes V and VI differ in the amounts of OMS propellants available after boost

Mode III Abort Timeline -- Return to Launch Site, Suborbital

Automatic Orbiter Operations -- Abort Analysis, Initiation, and Sequencing

Perform Situation Analysis

Make Preliminary Abort Decisions

Report Status to Ground

Obtain Concurrence with Flight Data Base for Abort

Obtain Abort Confirmation

Display Condition/Status/Abort Command to Crew -- Crew will have a brief period for the abort command notification, except in the time-critical transition from Mode III to Mode IV abort at T+121 to T+126. Reaction time must be very fast to obtain Mode III return to launch site when a Mode IV OAO is not yet achievable. Command over-ride for abort is not feasible at this time, but a recheck may be commanded when response time is sufficient.

## Automatic Orbiter Operations -- Abort

Reprogram Flight Control/GNC to Abort Mode III

Insert Abort AV Adjustment in Engine Thrust Program

Switch Engines to EPL (109%), Assuming Engine Failure Precipitated Abort

Ignite Two OMS Engines and Four RCS X-Axis Thrusters (Orbiter)

Pitch Orbiter to Retro-Thrust Attitude

Verify Emergency Thrust/Velocity/Attitude per Abort Mode III Program

Change Orbiter Velocity from Down-Range to Up-Range

Verify Dump/Vent Valve Positions/Status

Activate Abort Dump System

Open LO<sub>2</sub> Abort Dump Valve (3-inch line)

Open Helium Pressurization Valve

Verify LO, Dumping (A2V or AV readout, visual, etc.)

Verify 20% Minimum to 40% Maximum LO2 Dump Completion

Reclose and Verify Helium Pressurization Valve Closure

Reclose and Verify LO2 Dump Valve Closure

Separate External Tank (ET) After Depletion

Establish Attitude and G-Profile for Dumping

Fly an Orbiter Return Flight Profile as Appropriate for Abort Mode III

Open LO<sub>2</sub> Abort Dump Valve (3-inch line)

Open Helium Pressurization Valve

Verify LO2 Dumping.

Monitor LO, Tank Pressure

At 15 psia  ${\rm LO}_2$  Tank Pressure, Reclose and Verify Helium Pressurization Valve Closure

Reclose and Verify  ${\rm LO}_2$  Abort Dump Valve

Monitor LO<sub>2</sub> Tank Pressure and Vent Ebove 18 psia down to  $16 \pm 1$  psia

Monitor LH<sub>2</sub> Tank Pressure and Vent Above 18 psia down to 16 ± 1 psia Note: Interlock Vent Control to Avoid Simultaneous Venting to different altitudes and inclunations. These do not appreciably affect the abort operations. There are about 105 minutes in a Mode IV Once-Around-Orbit (QAO) abort, of which at least 90 minutes are available for dumping cryogens. The later Modes V and VI have many orbits and are not time constraining, as they allow essentially normal mission Orbiter operations. Release of the Tug may be possible. The timeline for these short modes is shown in Table 6.1-2.

## Modes IV, V, and VI Abort Timeline - Orbital

Automatic Orbiter Operations -- Abort Analysis, Initiation and Sequencing

Monitor Orbiter and Tug Mission - Critical Functions and Flight Data During Launch

Perform Situation Analysis

Make Preliminary Abort Decisions

Report Status to Ground

Obtain Concurrence with Flight Data Base for Abort

Obtain Abort Confirmation

Display Condition/Status/Abort Command to Crew (\*Note 1)

Automatic Orbiter Operations -- Abort

Reprogram Flight Control/GNC to Abort Modes IV, V, or VI (normal mission for V, VI)

Insert Abort AV Adjustment in Engine Thrust Program

Switch Engines to EPL (100%), Assuming Engine Failure Precipitated Abort

Ignite Two OMS Engines and Four RCS X-Axis Thrusters (Orbiter) for Mode IV (not required for Modes V and VI)

Verify Emergency Thrust/Velocity/Attitude per Abort Modes IV, V, or VI Program

Verify Dump/Vent Valve Positions/Status

Verify OMS Engine Thrust for Cryogen Settling

Activate Abort Dump System

Open LO, Abort Dump Valves (2-inch fill and drain and 3-inch aft abort lines)

Open Helium Pressurization Valve

Verify LO<sub>2</sub> Dumping (\$2 or AV resdout, visual, etc.)

Monitor LO, Tank Pressure

At 15 paia LO, Tank Pressure, Reclose and Verify Helium Pressurization Valve

Reclose and Verify LO2 Abort Dump Valve

During this Sequence, Interrupt Dumping 30 Seconds Before ET Jettison and Resume Dumping 30 Seconds After ET Jettison

Monitor LO, Tank Pressure and Vent Above 18 psia Down to 16 + 1 psia

Open LH, Valves to FILL and Drain and 2-inch Aft Abort Lines

The Following Operations Apply to Tug Options 1 and 3I Only:

Dump LH, Under Vapor Pressure to 3 psia

Reclose LH, Valves and Verify Closure

Open Helium Pressurization Valve

Monitor LH<sub>2</sub> Tank Pressure and Fill with Helium to 26.3 psia (or to Tank Relief Vent Pressure)

Reclose Helium Pressurization Valve and Verify Closure

Open LH2 Valves to Fill and Drain and 2-inch Aft Abort Lines

The Following Operations Apply to All Tug Design Options:

Dump LH, Under Vapor Pressure to 16 + 1 psia

Reclose LH, Valves and Verify Closure

Monitor LH2 Tank Pressure and Vent Above 18 psia Down to 16 + 1 psia

\*Hote 1: Crew will have a brief period for the abort command notification, except in the time-critical transition from Mode III to Mode IV abort at T+121 to T+126.

Reaction time must be very fast to obtain Mode III return to launch site when a Mode IV OAO is not yet achievable.

Command over-ride for abort is not feasible at this time, but a recheck may be commanded when response time is sufficient.

Note 2: Interlock went controls to avoid simultaneous dumping.

Note 3: An alternative LO<sub>2</sub> dump mode is to dump up to 40% through the 3-inch LO<sub>2</sub> abort line (bottom port) rather than the aft 2-inch fill and drain line tap to the 3-inch aft abort line port. In this event, the remaining LO<sub>2</sub> dump to 15 psia is accomplished after reentry during glide return.

Hote 4: An alternative LH<sub>2</sub> dump mode is to keep all LH<sub>2</sub> in tank and only vent above 18 psis.

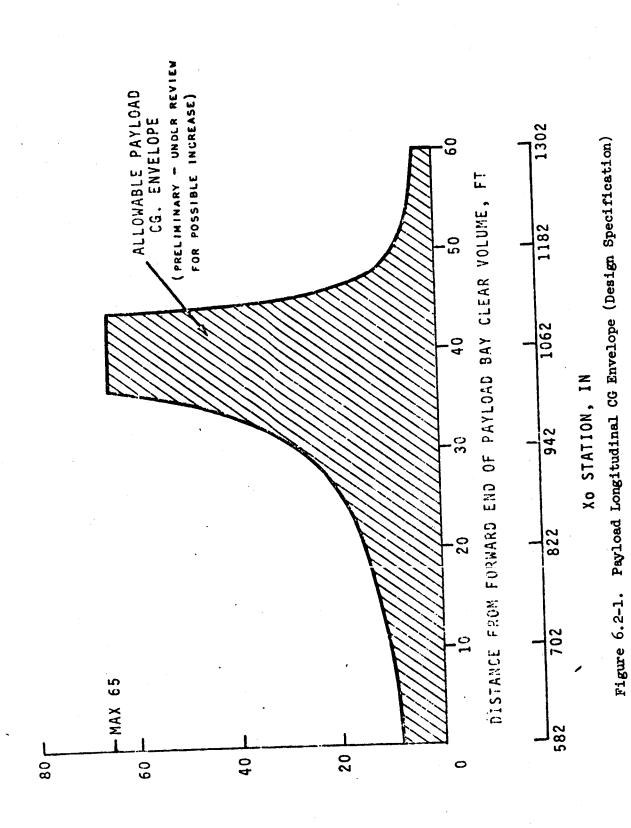
### 6.2 Shuttle Requirements

The Shuttle requirements placed upon the Tug operation are principally described by NASA Document JSC-07700, Volume XIV, Space Shuttle System Payload Accommodations. For example, the CG profiles shown in Figures 6.6.2-1 and 6.6.2-2 represent major constraints upon the Tug design and operations. These apply when the ET is jettisoned and the Orbiter is in sensible atmosphere, generally considered below 400,000 ft, in the aerodynamic flight regime. Specifically, these apply in hypersonic and subsonic, but not in supersonic flight. Safety dictates that CG compatibility be achieved before the unstable flight regime is approached, however. Furthermore, a condition where failure to dump cryogens would result in unsafe flight should be avoided. Two methods are provided for dumping a minimum of 20% of LO<sub>2</sub>, which is sufficient to assure CG compatibility for recentry and landing.

The Shuttle also requires discrete valve status signals and time-clock inputs to compute the cryogen inventory during dumping. In particular, the  $\approx 40\%$  orbital LO<sub>2</sub> dump in the Alternative (Backup) Method must be computed for valve reclosure to prevent unporting and a sudden drop of pressure, which if not recovered could cause a risk of LO<sub>2</sub> tank implosion at low altitude. In the selected Primary Method, the aft 2-inch LO<sub>2</sub> fill and drain line port is used, and unporting cannot occur during propulsive dumping. The latter method is also used for orbital LH<sub>2</sub> dumping, through the fill and drain line port and unporting is not a potential problem. Suborbital dumping has a requirement for computing LO<sub>2</sub> inventory for partial dumping of 20% to 40%, but this wide range allows the data and the computations to be very gross.

### New Shuttle Requirements

The selected abort dumping system requires a fixed 3-inch LO<sub>2</sub> abort dump line from the lower right aft cargo bay bulkhead to the lower right Orbiter boat-tail.



PAYLOAD WEIGHT, 1000 LBS

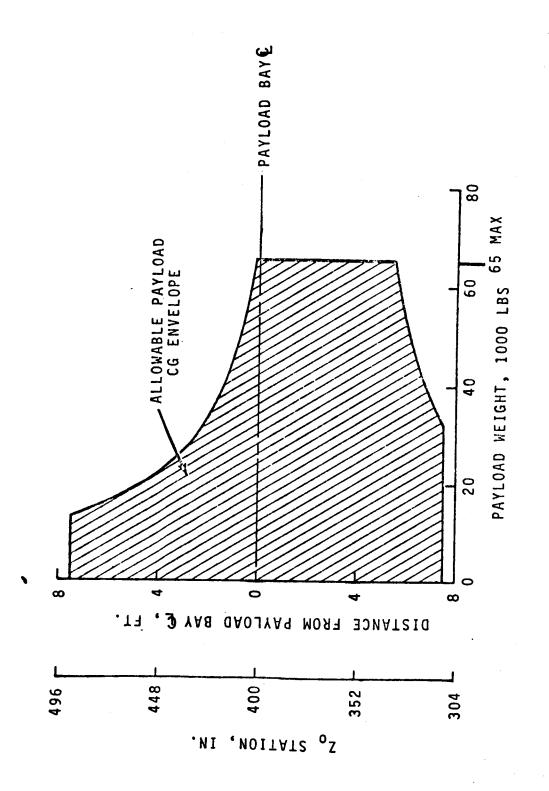


Figure 6.2-2. Payload Vertical CG Envelope



and a similar 2-inch LH<sub>2</sub> abort dump line (for orbital abort) from the lower left aft cargo bay bulkhead to the lower left Orbiter boat-tail.

### 6.3 Altitude and Time Analysis

The altitude of the Orbiter is shown in Figures 6.3-1, 6.3-2, 6.3-3, and 0, 6.3-4 for suborbital Mode III aborts as a function of velocity. Insufficient data was provided to obtain an altitude versus time profile for these trajectories, which were revised extensively during the study. Information on normal trajectories was referenced by NASA documentation as IL-SSS-393-400-73-C45, "Baseline Ascent Trajectories for the 150K Orbiter Configuration," dated February 14, 1973, but this information was also withheld from this study. Earlier information indicated that at least 105 minutes are available on a Mode IV abort to a once-around orbit. This is the shortest orbital abort, and the time available is far greater than the time required for 100% dumping of both LO<sub>2</sub> and LH<sub>2</sub>. Mode V is a transitional abort and is virtually identical, time-wise, to a Mode VI normal mission orbital abort. Thus the missing information is not considered relevant to constrain the time-lines.

Summaries of abort modes, associated flight periods and the abort response  $\omega$  actions permissible are shown in Table 6.3-1.

The time available for the most recent abort profile data (July 5, 1973), the altitudes, the associated mission times, the x-axis accelerations ( $N_x$ ) and the z-axis accelerations ( $N_z$ ) are listed in Tables 6.3-2 and 6.3-3. The time periods during which stable and variable (stable-plus-varying) accelerations are sustained for cryogen settling are also shown.

An abort time summary is presented in Table 6.3-4 for either  $LO_2$  or  $LH_2$ . for the early or late abort from either a 40,000 lb polar or a 65,000 lb easterly mission.

// Figure 6.3-1

Figure 6.3-

O LOSS OF ONE MAIN ENGINE O ROWINDS O NO WINDS			ABORT START 655 SEC X 628.2 SEC	GLIDEBACK	Krt/Sec
DA ORBITER ASCENT ABORT MODE III  O EASTERLY MISSION O TABORT = 116.334 SEC	0001	300 HEADING FEWERSAL	200 200 828 SEC	100 ORBITER GLIDI	1343 SEC 1 2 3 th

Figure 6.3-3

;

				r START											
				Q ABORT									6		
COFILE								BURNOUT	9 SEC				<b>6</b>		
- ALTITUDE-VELOCITY PROFILM O LOSS OF ONE MAIN ENGINE O MAIN FROTHES AT 109% EPL								0					9		
ALTITUDE  O LOSS OF ON	NO WINI								592				2	:	
NOOR III	•									726 SEC	GLIDEBACK			OCITY - KF	
ASCENT ABORT RLY MISSION	E .										OFBITER		3		
LM ORBITER ASCENT  O EASTERLY ME	O TABORT												. ~		
					HEADING	REVERSAL					) DEC 98	X	SEC 1		
			100		300 HEAT			500			100	1 :	1241		
			:				KILI KILI	- a	inii	TJA	•				

Figure 6.3-4

Table 6.3-1

# ABORT DUMP ANALYSIS

## ABORT MODES

REFERENCE: NASA-JSC-ME-12-833 (ABORT TRAJECTORIES FOR MISSION 3A, PRELIMINARY), MODIFIED BY COR DIRECTION IN MSFC-PD-TUG-6-73-146 FOR MODE III ABORT.

RETAIN LOX, CONTINUE TO MODE II OR III; OR OCEAN DITCH INTACT AFTER T+20 SEC	ABORT NOT PERMITTED UNTIL SRB SEPARATION AT T+116; CONTINUE TO MODE III ABORT AT T+116	512 SEC POWERED PLUS 715 SEC GLIDE AVAIL FROM T+116 (INCLUDING 95 SEC ERRATIC AND 593 SEC STEADY PROPELLANT SETTLING PERIODS) 310 SEC POWERED PLUS 680 SEC GLIDE AVAIL FROM T+251 (INCLUDING 134 SEC ERRATIC AND 515 SEC STEADY PROPELLANT SETTLING PERIODS)	105 MINUTES AVAILABLE 220 SECONDS REQUIRED FROM T+330 TO INSERTION
FLIGHT TIME (SEC) 0-36	36-86	80-253 T+116 EASTERLY T+251 EASTERLY	253-330 N/A 330 TO INSERTION
ABORT MODE	II (GLIDE)	III (RTLS)	IV (AOA) V (ATO) VI (NORMAL MISSION)

RTLS = RETURN TO LAUNCH SITE

AOA = ABORT ONCE AROUND

ATO = ABORT TO ORBIT

Table 6.3-2

NEW ABORT PROFILE DATA

5 JULY 1973

EARLY MODE III ABGRT

SRB THRUST TERMINATION AT T + 116.334 SEC

ABORT INITIATED AT T + 121 SEC OMS BURNOUT:

T + 249.314 FOR 40K LB POLAR FLIGHT

T + 512.534 FOR 65K LB DUE EAST FLIGHT

MAIN ENGINE BURNOUT:

T + 628.205 FOR BOTH FLIGHT PROFILES

	POLA	POLAR ORBIT		DUE	UE EAST ORBIT	ίΤ
ALTITUDE	E	×	Nz	TIME	×	Nz
190K FT	628.2* +3.5+0	+3.5+0	+0.5+0		3.15+0	628.2* 3.15+0 +0.55>0
150	<b>299</b>	-0.1	-1.45	655	-0.05	-0.85
100	878	-0.2	-1.0	828	-0.2	-1.0
20	1088	-0.15	-1.0	1038	-0.25	-1.1
LAND	1393	0	-1.0+0	1343	0	-1.0%

\* MECO - MAIN ENGINE CUT OFF

STABLE REGIONS:

POLAR MISSION: T + 770 TO 1393 LANDING

110 SEC TO 110 K FT

DUE EAST MISSION: T + 750 TO 1343 LANDING

< 78 SEC TO 110K FT

VARIABLE REGIONS:

POLAR MISSION: T + 667 TO 1393

203 SEC TO 110 K FT DUE EAST MISSION: T + 655 TO 1343 173 SEC TO 110K FT Table 6.3-3

DATA PROFILE ABORT X W N

5 JULY 1973

LATE MODE III ABORT

SRB THRUST TERMINATION AT T + 116.33.4 SEC

ABORT INITIATED AT T + 256 SEC (40K LB POLAR, AT T + 251 SEC (65K LB DUE EAST) OMS BURNOUT:

T + 388.98 FOR 40K LB POLAR

T + 560.863 FOR 65K LB DUE EAST

MAIN ENGINE BURNOUT:

T + 558.7 FOR 40K LB POLAR

T + 628.2 FOR 65K LB DUE EAST

At TTTINE	POLA	POLAR ORBIT		DOE	UE EAST ORBIT	17
ALITIONE	TIME	×	Nz	TIME	×	NZ
175K FT	£58.7*	+3.5-0	558.7* +3.5-0 +0.6-0			
180K FT				\$60.9*	+3.2-0	+0.4-0
150K FT	594	-0.1	-0.95	265	-0.05	-1.25
100K FT	622	-0.2	-1.0	726	-0.2	-1.1
50K FT	686	-0.15	-1.05	936	-0.15	-1.05
LAND	1294	0	-1.0 1241	1241	0	-1.0

\* MECO - MAIN ENGINE CUT OFF

POLAR MISSION: T + 700 TO 1294 LANDING 75 SEC TO 110K FT STABLE REGIONS:

DUE EAST MISSION: T + 726 TO 1241 0 SEC TO 110K FT

POLAR MISSION: T + 594 TO 1294 181 SEC TO 110 FT DUE EAST: T + 592 TO 1241 134 SEC TO 110K FT VARIABLE REGIONS:

Table 6.3-4 TIME

	ГОХ		LH2	
	STABLE	VARIABLE	STABLE	VARIABLE
	(SEC)	(SEC)	(SEC)	(SEC)
LY ABORT (T+121)				
40KLB POLAR MISSION	623	726	001	203
65KLB DUE-EAST MISSION	593	989	78	173
E ABORT (T+256, 251)				
40KLB POLAR MISSION	594	700	75	181
65KLB DUE-EAST MISSION	515	649	0	134

O EARLY ABORT (T+121)

"VARIABLE" INCLUDES ALL TIME IN WHICH PROPELLANTS ARE UNDER G-FORCES TO COVER THE DUMP OUTLET, WITH BOTH STABLE AND VARYING ACCILLERATION VALUES.

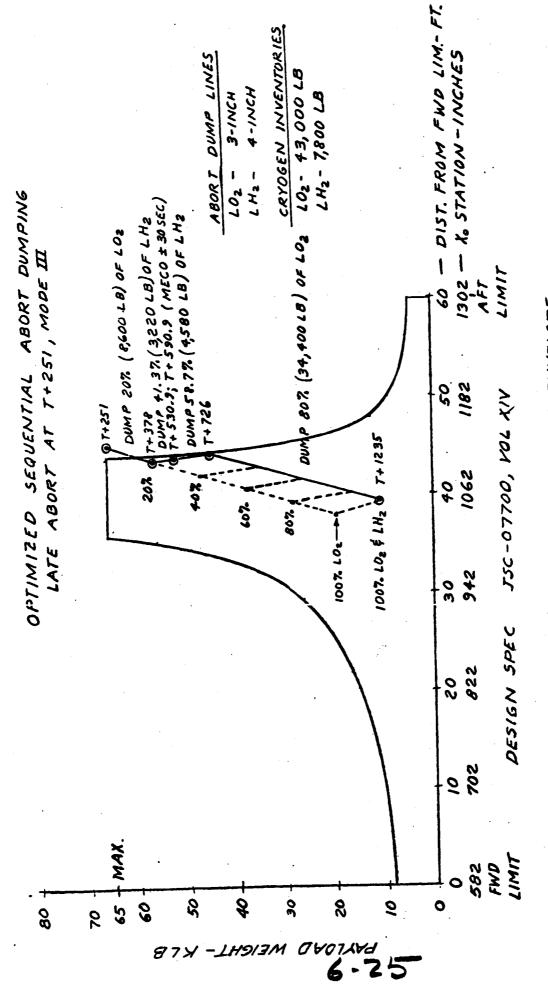
o LATE ABORT (T+256, 251)

A plot of the cryogen load and center of gravity (C.G.) shift during dumping is shown on Figure 6.3-5. This was originally derived to illustrate the cases of sequential dumping. However, the complexity of alternating the  $\rm LO_2$  and  $\rm LH_2$  dumping sequence and the weight penalty on payload capability led to the recommendation that only  $\rm LO_2$  be dumped during a suborbital abort.

Combining the trajectory vs. time data from Figure 6.3-4 and the C.G. constraints from Figure 6.3-5, a safe timeline was devised to provide the Orbiter  $\Delta$  V benefit of early dumping, the C.G. constraints to assure aerodynamic stability and landing control as early as possible, and a 100% release of LO<sub>2</sub> will before landing. This recommended abort mode is shown on Figure 6.3-6. The LO<sub>2</sub> dumping is interrupted for 60 seconds as indicated to allow for main engine cutoff (MECO) and external tank (ET) jettison and a 30 second margin before and after this event.

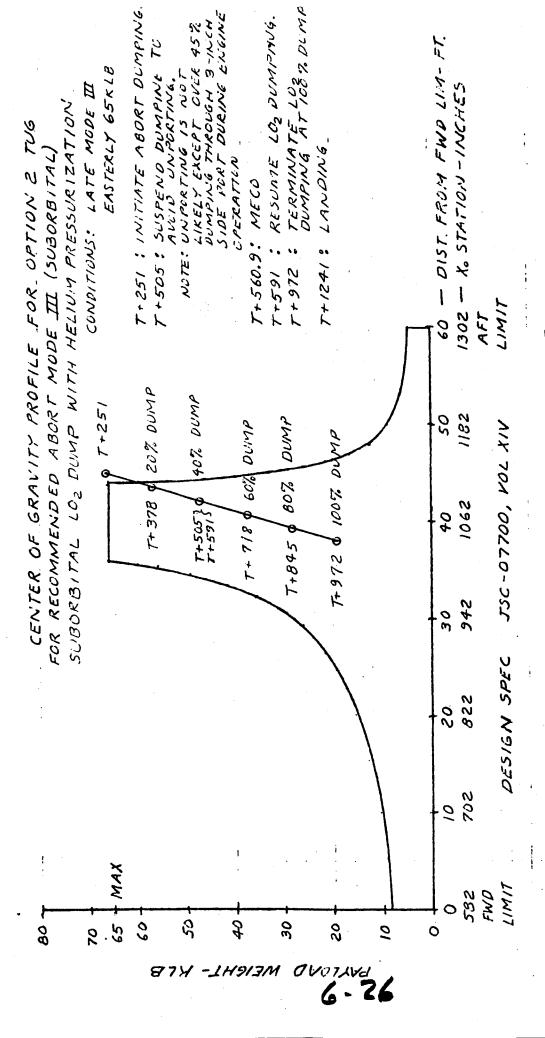
The  $LO_2$  dumping sequence is shown on the trajectory curve in Figure 6.3-7. The same time periods are required for dumping  $LO_2$  (635 seconds total) for the trajectories shown in Figure 6.6.3-1, -2, and -3. However, in each case, more time is available from the abort decision to MECO - 30. Therefore, as it is recommended to initiate dumping as early as possible; these trajectories will allow a greater degree of completion prior to MECO - 30.

This analysis is based on the worst-case data for Tug Design Option 2, which requires 635 seconds for 100%  $LO_2$  dump. The differences in  $LO_2$  inventory result in equivalent times for  $LO_2$  dump of 505 seconds for Tug Option 1 and 3I (Initial) and 530 seconds for Tug Option 3F (Final). In each case the dump is suspended at 40% dump level, which occurs at proportionally earlier times. The event schedules are shown in Table 6.3-5 for comparison.



PAYLOAD LONGITUDINAL CG ENYELOPE

Figure 6.3-5



PAYLOAD LONGITUDINAL CG ENVELOPE

Figure 6.3-6

MODE III — ALTITUDE-VELOCITY PROFILE  o LOSS OF ONE MAIN ENGINE  o 2 MAIN ENGINES AT 109% EPL  o NO WINDS	TUG DESIGN OPTION 3		START I.A. DUMPING	O 251 SEC. ABORT START	D LOZ DUMPING AT 40% DUMP ON OPTION 31 (INITIAL DESIGN). PEND LO, DUMPING AT 40% DUMP ON OPTION 3P (FINAL 'DESIGN)		592 SEC NE BURNOUT	726 SEC FESUME LOS BUNERAG	RBITER GLIDEEACK LO. DUMPING AT 100% DUMP ON OPTION 31 (INITIAL DESIGN)	WEING AT 100% DUMP ON OPTION 3F (FINAL DESIGN)	1	
LW ORBITER ASCENT ABORT MODE  O EASTERLY MISSION  O INPLANE MANEUVER  O TABORT = 251 SEC		001			REVERSAL (453 SEC - SUSPEND LOZ DU REVERSAL (451 SEC - SUSPEND LOZ DU	Lix -		100 100 100 100 100 100 100 100 100 100	ALE SEC 908 SEC 18 986	<b>5</b> .	1241 SEC 1 2 3 14	

Table 6.3-5

### ABORT EVENT SCHEDULES

TUG OPTION	1	2	31	3F
LO <sub>2</sub> ABORT LINE SIZE	3 inch	3 inch	3 inch	3 inch
TIME FOR 100% LO2 DUMP	505 sec	635 sec	505 sec	530 sec
DUMP INITIATION (WORST CASE)	T+251	T+251	<b>T+251</b>	<b>T+251</b>
DUMP SUSPENSION	T+453	<b>T+505</b>	<b>T+</b> 453	<b>T+463</b>
MECO	T+560.9	T+560.9	<b>T+</b> 560.9	<b>T+560.9</b>
DUMP RESUMPTION	T+591	T+591	<b>T+</b> 591	T+591
DUMP COMPLETION	T+894	T+972	<b>T+</b> 894	<b>T+909</b>
TIME AT 50,000 FT	т+986	т+986	т+986	T+986
TIME AT LANDING	T+1241	T+1241	<b>T+1241</b>	T+1241

### 6.4 Delta V Analysis

6

Two aspects of abort delta V were examined. The first is concerned with the delta V produced by the propulsive dumping which is necessary to sustain propellant settling in an orbital zero-g abort. The second is concerned with the potential delta V gain which is achievable by the Orbiter by early Mode III abort dumping after as much of the Orbiter wieght has been depleted as possible; hence, after External Tank (ET) propellants are exhausted and the ET has been jettisoned to achieve the highest delta-V gain

### Delta V Compensation in Orbital Abort of LO2 and LH2

Addressing the first aspect, delta V compensation in an orbital abort, the potential solutions all require that the propulsive effect expressed by Orbiter delta-V be negated. Potential solutions are (1) reduced thrust from the OMS, RCS x-axis thrusters, or the main engines, (2) reduced thrusting time by the OMS, RCS x-axis thrusters, or the main engines, (3) rotation of the Orbiter during cryogen dumping to retro-thrust for a time equal to the forward thrust

time, using the cryogen expulsion force, (4) yaw to +90° and to -90° to provide equal and opposite thrusting forces and times, (5) dump Tug cryogens before the OMS or the main propulsion system (MPS) burns, (6) dump Tug cryogens during OMS and/or MPS burn, (7) interrupt OMS and/or MPS burns to save sufficient propellant and adjust the delta V with a shorter final burn duration, or (8) use a computed abort delta V to bias (shorten) the OMS and/or MPS burns and thus to compensate for abort delta V. It should be noted that these solutions use either (1) a "thrust-spoiling" or counter-reactive negation technique, or (2) a "compensation" technique in connection with major propulsion systems and in these cases, excess cryogen is jettisoned with the ET in the cases of reduced MPS burns or is dumped before reentry in the cases of OMS burns. It should be emphasized that the OMS burn adjustment therefore only transfers the problem from Tuz to Orbiter, and thus represents no real solution.

The propulsive abort dumping delta V problem applies only to orbital abort primarily due to the more precise reentry velocity and time constraints from orbit. The plan to dump during main engine burn will minimize the problem for a suborbital abort, and adjustment of velocity is more readily accomplished to compensate for cryogen dumping.

The dumping delta V problem, discussions, and conclusions are characterized for a once-around-oribt (OAO) Mode IV abort as representatige of all orbital abort modes.

### Delta V Compensation for Once-Around-Orbit (OAO) Abort Dumping

This discussion represents an operational solution to a problem raised by an action item question and a NASA response, quoted below. The NASA response reflects one solution to the potential problem. However, it is very constraining to limit abort dumping to the Orbiter thrust period alone, and other options have been examined.

Reference: NASA-MSFC Memorandum PD-DO-DIR-73-57, dated June 7, 1973, extract:

"Action Item 2: Can Tug propellants be dumped in the X axis of the Orbiter to provide propellant settling during the once around abort (OAO) mode?

Response: In discussions with JSC we were told that the OAO abort trajectory after Orbiter thrust termination is critical and may not be able to correct for any  $\Delta V$  resulting from propellant settling thrust and Tug propellant dumping. JSC therefore requested that any Tug propellant dumping during an OAO abort should be completed before Orbiter thrust termination so that the  $\Delta V$  imparted by the propellant dumping can be corrected!

### Alternatives

- 1. Reduced thrusting forces from OMS, MPS, or RCS (x-axis).
- 2. Reduced thrusting time for OMS, MPS, or RCS (x-axis).
- 3. Rotation to 180° and retro-thrust.
- 4. Rotation to +90° and -90° and counter-thrust.
- 5. Dump before OMS, MPS, or RCS burns.
- 6. Dump during OMS, MPS, or RCS burns.
- 7. Interrupt OMS, MPS, or RCS burns and adjust AV with final burn duration.
- 8. Use a computed abort  $\Delta V$  to bias the OMS, MPS, or RCS burn and thus compensate for abort dump  $\Delta V$ .

### Analysis

1. Thrust management of OMS or MPS during the late burn period is more effective than early adjustment, due to the lower total weight. A more accurate result is obtained by adjusting the total thrust (abort dump thrust plus primary propulsive thrust) to match the programmed flight requirements.

The best alternative is to reduce MPS or RCS rather than OMS thrust level, so the unused propellant is either jettisoned (MPS) or returned (RCS), assuming either OMS burn or propulsive dumping is baselined for an aborted mission.

- 2. Thrust-time management of OMS, MPS, or RCS is similar to alternative No. 1, and is effective to the same degree. The programmed total thrust technique, however, must be changed to a programmed total impulse technique using accelerometers and a clock to determine delta V and to match the programmed orbital abort flight profile. Again, it is best to use MPS or RCS as the adjustable propulsion energy source, depleting OMS propellants completely.
- 3. Retro-thrust management represents some control complexity and relies on computed delta V. using acceleration and time as inputs, as the control variable. This is an effective method if it is operationally acceptable to the Orbiter.
- 4. Left and right yaw thrust management is the same as alternative No. 3 in most respects. It can be used to effect any desired cross-range adjustment, as well.
- 5. Dump before MPS burn is not practical, since MPS burns from launch. OMS burn is started later, and could be delayed. However, the dumping time for LO<sub>2</sub> and LH<sub>2</sub> would usually exceed the OMS ignition delay time and the dump would be at least partially concurrent with OMS burning.
- 6. Dump during MPS and OMS burn is possible; however, a Mode IV abort is initiated from T+253 to T+330 seconds, a Mode V from T+330 to T+490 seconds, and a Mode VI (normal mission orbit) after 550 seconds. Considering the delta V problem for orbital abort only (Mode IV or later), it is evident that a limited time is possible for a programmed simultaneous MPS burn with the T+256 Mode IV abort initiation. A variable amount of excess propellant is available for later burns and the dumping of Tug cryogens can be compensated by retaining an equivalent amount of potential delta V in the MPS propellants stored in the ET. It is noted, for example, that the normal mission insertion in Mode VI is made with about 4,500 lb of cryogenic propellants in the ET. In a total dump of Tug LO<sub>2</sub> and LH<sub>2</sub> on orbit,

53,000 lb or more of cryogens are dumped, and an equivalent amount of ET propellant retention must provide about 58,500 lb-sec of reduced thrust for Option 2. This delta V compensation is 9.42 fps of Orbiter velocity gain, based on a 200,000 lb Orbiter with payload.

The main engines consist of three 470,000 lb thrust units (1,410 K lb total) for normal thrust to orbit, or two engines may be operated at 512.3 K lb each at 109% EPL (1024.6 K lb total) for abort thrust to orbit. Therefore, with either normal thrust or emergency thrust, the thrust time reduction is 0.041 or 0.057 seconds to compensate for later propulsive cryogen dump delta V from Tug tanks. Calculation shows that 132.2 lb of MPS propellant is equivalent to 100% Tug cryogen dumping.

Delta V trimming is much simpler with OMS, if nonpropulsive OMS dumping is available, and the two 6,000 lb OMS thrusters would be operated for 4.88 seconds less time and would save 0.94% of inventory.

The four 900 lb RCS aft x-axis thrusters would reduce RCS operation time by about 16.3 seconds of net aft thrusting time to compensate for 100%.

Tug cryogen dumping.

7. The discussion under alternative No. 6 incorporates the data to define either an interrupted OMS or an interrupted MPS burn. The difference lies in the option to interrupt earlier, then to compute the necessary time, thrust level, and engine selection for a reduced later OMS or MPS burn after Tug dumping has been completed. Computation of the delta V gain from acceleration and time measurements to determine a reduced remaining delta V desired would then establish a new burn profile for the crew or Orbiter propulsion management system.

8. Use a computed abort delta V to bias the OMS, MPS, or RCS burn and thus compensate for abort dump delta V. This is a pre-flight computation. This is a refinement to alternative No. 7 and should be adequate to avoid interrupted burning for abort delta V compensation. This computation is based on a known weight of cryogen, a known helium pressure, and a known abort dump line diameter, thus yielding a known propulsion energy and thrust. If the abort dump initiation time and duration are known, the mass of the Orbiter will be known and the delta V can be calculated. For each particular mission, the total mass of Orbiter plus Tug plus payload will be known. Abort dumping after ET jettison therefore will impart a delta V which will be known before mission launch. A brief reduction of MPS, OMS, and/or RCS burns can be established before launch and programmed into the engine control system. The simplicity of this method leads to a recommendation that it be incorporated in the operational technique for the mission.

### Computation of Abort Dump Delta V Compensation

$$\Delta V = \frac{g \times I_{sp} V_{prop}}{V_{orb}}$$

Required Total Negative Impulse = Total Tug Dump Positive Impulse

= 25 1b x 1,100 sec for LH<sub>3</sub> + 50 1b x 620 sec for LO<sub>2</sub>

= 27,500 + 31,000

= 58,500 lb-sec

$$\Delta V = \frac{g \times Impulse}{V_{orbiter}} = \frac{32.2 \times 58,500}{200,000}$$

= 9.42 ft/sec = Orbiter  $\Delta V$ 

### RCS Compensation

4 x 900 lb thrust = 3,600 lb total RCS thrust available

Total impulse available = 2,806 lb x 289 second  $I_{gp}$  = 810,934 lb sec

Usec 58500/810,934 = 7.2% less of the RCS inventory or 202.4 lb less of 2,806 lb total. This is a desirable gain

Thrust time duration = 58,500 = 16.25 seconds less time 3.600

### Additional Commentary

MPS, DMS, RCS burn times were computed for Orbiter Mass above. OMS and RCS value are correct as shown for burns after ET jettison.

Since MPS burn occurs while the ET is on board, the mass should be with the empty ET plus 50% of the necessary AV propellant in the ET. This provides for a MPS burn that is shortened in duration.

Since Orbiter AV = 9.42 fps, calculate reduced MPS time from the total MPS thrust and average weight:

Approx 
$$W_{PROP}$$
 =  $\Delta V (W_{Orbiter} + W_{PL} + W_{TUG} + W_{ET} + W_{PROP/2})$   
 $g \times I_{sp}$   
=  $9.42 (155 + 78 + ^ 0.1) \text{ klb}$   
 $32.2 \times 442.5$   
=  $9.42 \times 288.1 \times 1000 = 190.4 \text{ lb}$   
 $32.2 \times 442.5$   
Exact  $W_{Approx}$  =  $9.42 \times 288.095 \times 1000 = 190.5 \text{ lb}$ 

Exact  $W_{PROP}$  =  $9.42 \times 288.095 \times 1000$  = 190.5 lb

This is comparable to the value of 132.2 lb computed previously from Orbiter weight alone, and applies to Alternatives #2 and #8. If an interrupted burn, Alternative #7, is used, more propellant will be expended for an earlier interruption period, because the AV gain per unit of expended propellent is less and must be made up later.

### MPS Compensation

Three engines at normal thrust for 116 sec:

 $3 \times 470 \text{ K lb} \times 116 = 163,560 \text{ K lb-sec}$ 

Two engines at EPL (109%) for 512 sec:

 $2 \times 512.3 \text{ K lb} \times 512 = 524,595 \text{ K lb-sec}$ 

Orbiter Total Inventory = 688,155 K lb-sec

External Tank (ET) holds 1,555 K lb of propellant (usable):

Then specific impulse  $I_{sp} = \frac{688,155 \text{ K lb-sec thrust}}{1,555 \text{ K lb propellant}}$ 

= 442.5 seconds

 $\frac{W_{PROP}}{I_{sp} \times q} = \frac{\Delta V \times W_{ORB}}{442.5 \times 32.2} = 132.2 \text{ lb of ET propellants}$ 

This is 132.2 = 0.0085% of the ET inventory 1,555,000

Orbiter burn durations are computed as follows:

Three engines @ 100% Normal 58,500 = 0.041 sec

1,410,000

OMS Compensation

 $\frac{\Delta V_{\text{REQD}}}{\Delta V_{\text{AVAIL}}}$  = 9.42 = 0.94 % of total OMS inventory

2 x 6000 lb thrust = 12,000 lb total OMS thrust Thrust time duration = 58,500 = 4.88 seconds 12,000 lb Objective. Assess the effect on  $\Delta V$  as a result of dumping LO<sub>2</sub> during the main engine burn period after SRB jettison in a suborbital abort Mode III. Assume for this analysis that LO<sub>2</sub> dump is compatible with engine burn and that appropriate lines are available for such dumping.

Analysis. Two of the three main engines are assumed operable during an abort. These produce  $2 \times 470 \text{K}$  lb. of thrust and are operated at EPL of 109% of nominal thrust, or 109% x 470K = 512.3K lb. each and 1024.6K lb. total. Two OMS pods will also be operating at 6K lb. thrust each. Total thrust, then, is 1024.6 + 12 = 1036.6 K lb. The weight schedule as a function of launch events is shown in Table 6.4-1.

Table 6.4-1
SHUTTLE ASSEMBLY WEIGHT DATA

Ascent Weight	Orbiter	Ext. Tank	SRB	Total
Liftoff (T - 0)	207K	1633K	2327K	4167K
Pre-SRB Sep (T + 115)	207	1280	309	1796K
Post-SRB Sep (T + 116)	207	1280	-	1487K
Pre-ET Sep (T + 628.2)	207	78	-	285K
Post-LT Sep (T + 629.2)	207		- -	207K
	Orbiter	P/L	Cryogens	Total
Orbiter Landing (T + 1343)				
Empty Cargo Bay	155K	-	-	155K
Min. Tug/PL Wt	. 155	25	-	180K
Mod. Tug/PL Wt	155	33	- · · · · · · · · · · · · · · · · · · ·	188K
Mod. Tug/PL Wt	155	25	8	188K

Averaging the weight at the beginning and end of thrust gives a value for  $\Delta V$  calculation.

Option 1 has 43746 lb. LO<sub>2</sub> and 7954 lb. LH<sub>2</sub> (51,700 lb. total).

Option 1 (Rev.) has 50,850 lb. total at 5.5:1, or 43,027 lb.  $\rm LO_2$  and 7,823 lb.  $\rm LH_2$ .

Option 2 has 55,500 lb. total at 6:1, or 47,571 lb.  $LO_2$  and 7,929 lb.  $LH_2$ .

Option 3 has 54,450 lb. total at 5.5:1, or 46,073 lb.  $LO_2$  and 8,377 lb.  $LH_2$ .

A 3 inch line will drain 7655 lb. of LH<sub>2</sub> in 410 sec @ 18.67 lb/sec; or 45,930 lb. of LO<sub>2</sub> in 630 sec @ 72.90 lb/sec. A 5 inch line will drain 7655 lb. of LH<sub>2</sub> in 130 sec @ 58.88 lb/sec; or 45,930 lb. of LO<sub>2</sub> in 200 sec @ 229.65 lb/sec.

Assume an early Mode III abort initiated at T + 121 secs., 40K lb. solar flight.

Case 1 Dump LO<sub>2</sub> only (assume an aft 3-inch line) 630 sec in 3 inch line, (507.2 sec during burn)

Initiation: T + 121, 1036.6K lb. thrust, 1487K lb. wt.

OMS burnout: T + 249.3, 1024.6K lb. thrust, 1174.2K lb.

Main engine burnout: T + 628.2, 0 thrust, 285K lb.

$$\Delta V = \frac{g I_T}{W_{AVG}} = \frac{32.2 \times (128.3 \times 1036.6K)}{(1487 - 1174.2)/2} + \frac{(378.9 \times 1024.6K) \times 32.2}{(1174.2 - 285)/2}$$

$$\Delta V_1 = \frac{32.2 \times 128.3 \times 1036.6K}{1330.6K} + \frac{378.9 \times 1024.6K \times 32.2}{728.6K}$$

= 3218.4

+ 17,157.2

= 20,375.6 fps if no  $LO_2$  has been dumped.

Now calculate the effect of LO, weight reduction by dumping:

LO<sub>2</sub> dumping reduces average wt. by  $\frac{72.9 \text{ lb/sec} \times 128.3 \text{ sec}}{2}$  = 4626.5 lb (avg)

1330.6K lb to 1324.0K lb during the first period and by  $\frac{72.9 \text{ lb/sec} \times 378.2 \text{ sec}}{2} = 13,810.9 \text{ lb (avg) from } 728.6\text{K lb to } 714.8\text{K}$ during the second period.

$$\Delta V_2 = 3218.4 \times \frac{1330.6}{1324.0} + 17157.2 \frac{728.6}{714.8} = 3234.4 + 17488.4 = 20,722.8 \text{ fps}$$

Therefore, the change in velocity  $(\Delta V_2 - \Delta V_1)$  due to dumping the maximum of 36,874.8 lb. of LO<sub>2</sub> after SRB jettison and before main engine burnout through a 3-inch line is computed to be from 20,375.6 fps up to 20,722.8 fps -- a potential change of 347.2 fps or about 1.7%.

Note: A 2-inch line is provided for vertical fill/drain. The 3-inch abort dump line is for sub-orbital dumping.

The total LO<sub>2</sub> dumped during main engine burn, therefore, is 9253 lb + 27,621.8lb = 36,874.8 lb, or about 85.7% for Option 1, 77.5% for Option 2, and 80.0% for Option 3. These values of dumping are not available through the side 3 inch abort dump port without unporting (this occurs at about 45% max.). It is therefore assumed for this analysis that a switch to the aft LO<sub>2</sub> port is made at 40 45% LO<sub>2</sub> dump to fully utilize the main engine burn period.

A late mode III abort will occur when much less propellant is in the External tank but has less effect on velocity gain due to the smaller average weight reduction during burn. Figure 6.6.4— illustrates this effect and the greater gain due to early abort dumping.

The conclusion is reached that a small but significant delta V is available for early dump during main engine burn, and the greatest gain is obtained from dump initiation immediately after the abort decision is made.

### 1. 4.

### 7.1 Methodology

Operational complexity may be defined as the number, duration, criticality and ease of completion of the combined events or functions that must be performed on the ground in order to accomplish the required Tug missions. Greater capability Tugs have increased complexity by virtue of their ability to perform payload retrieval through the addition of rendezvous and docking capability. The ability to handle spinning payloads and service orbiting payloads are further examples of added complexity due to increased mission capabilities. Low performance Tugs incur greater complexity by needing kick stages to achieve otherwise impossible missions. Autonomy level has a significant effect on complexity since it determines the proportion of events accomplished on the ground versus those performed on board the Tug. Complexity is also related to the number of critical events because contingency means must be provided for failure to successfully accomplish each critical event. Complexity increases with mission duration capability since a larger number of events are performed over the longer orbit stay times.

Evaluation of operational complexity does not readily lend itself to quantitative analysis. A qualitative examination of the applicability of the factors affecting complexity to a specific configuration is considered the most suitable approach to complexity assessment.

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Evaluation of operational complexity does not readily lend itself to quantitative analysis. A qualitative examination of the applicability of the factors affecting complexity to a specific configuration is considered the most suitable approach to complexity assessment.

### 7.2 Results/Conclusions

Option 3 includes two Tug configurations, an initial and a final. The initial configuration has low performance capability and no retrieval. Lack of rendez-vous, docking, and spin-up capability and short mission duration contribute to a low level of complexity. The number of critical events is low due to limited mission capabilities and duration which also results in low complexity. The low autonomy level (IV) increases complexity but the overall level is considered low.

The final configuration has high performance capability, rendezvous, docking and spin-up capability, longer (six-day) mission duration and a resulting high number of critical events. All of these factors incur high complexity levels as does the low autonomy level (III). The overall complexity level is considered to be high.

### 8 NETWORK/COMMUNICATIONS REQUIREMENTS

Subsequent to Concept Selection the COR directed that tracking and communication network costs be removed from the flight operations cost estimates and that network utilization requirements in hours be calculated instead for both the 15 station ground net and a 5 station TDRS net.

Since this determination requires timeline information it was necessary to base the calculations on the four reference missions for which timelines have been developed. Computations were made for each reference mission based on the following groundrules:

- a. Each main engine burn requires three ground contacts, i.e., uplink state vector update, downlink readiness report (with uplink burn enable or denial) and post burn downlink report. The times allotted for these contacts were 1, 2, and 2 minutes respectively.
- b. During long coast periods a Tug status report will be required every 8 hours. This contact will require 2 minutes.
- c. Ground tracking for orbit ephemeris determination is estimated to require a 3-minute track by each of 4 stations separated by at least a quarter of an orbit. Such a determination will be required prior to each main engine burn.
- d. Other contacts required during payload deployment, rendezvous and docking were determined from the timelines. These consisted mainly of uplink sequence initiation and post operation reporting.

Using these groundrules, the mission timelines and the orbit profiles, calculations were made to determine the number of passes and contact times required for each reference mission, below and above 5000 KM for each of the option/configurations. Option 1 and Option 3 Initial are the same while Option 2 and Option 3 Final are also alike.

Using the number of missions of each type for each option derived from the mission capture analysis, the total number of passes and contact times for each mission category was calculated. Combining the mission category totals produced a grand total for the complete program Options 1, 2, 3

Initial and 3 Final. Since these are estimates of requirements, they are independent of the network considered and will be the same for the 15-station ground net, the 5 station TDRS net or the AFSCF net.

A summary of network utilization requirement estimates are shown on the following pages.

### NETWORK OPERATIONS REQUIREMENTS

	Omtion 1	Option 2	Option	3
GEO-SYNCHRONOUS MISSION (REF MISSION a )	Option 1	ODULOR 2	Initial	Final
PER MISSION				
BELOW 5000 KM NUMBER OF PASSES CONTACT TIME (IN MINUTES)	29 70	29 70	29 70	29 70
ABOVE 5000 KM CONTACT TIME	49	128	49	128
NUMBER OF MISSIONS	113	105	82	131
TOTAL NUMBER OF PASSES	3277	3045	2378	3799
TOTAL CONTACT TIME (IN MINUTES)	13447	20790	9758	25938
				· ś
PLANETARY MISSION (REF MISSION $\gamma$ )	<b>l</b> .			
PER MISSION				
BELOW 5000 KM NUMBER OF PASSES CONTACT TIME	37 89	37 89	37 89	37 89
ABOVE 5000 KM CONTACT TIME	19	19	19	19
NUMBER OF MISSIONS	21	14	16	6
TOTAL NUMBER OF PASSES	777	518	592	222
TOTAL CONTACT TIME	2268	1512	1728	648
HIGH INCLINATION ELLIPTICAL MISSION (REF MISSION $\epsilon$ )				
PER MISSION				
BELOW 5000 KM  NUMBER OF PASSES  CONTACT TIME	28 68	28 68	28 68	28 68
ABOVE 5000 KM CONTACT TIME	45	57	45	57
NUMBER OF MISSIONS	56	57	22	51
TOTAL NUMBER OF PASSES	1568	1596	616	1428
TOTAL CONTACT TIME	6328	7125	2486	6375
	•		1	1

8-3

## NETWORK OPERATIONS REQUIREMENTS (Continued)

SUN SYNCHRONOUS POLAR MISSION (REF MISSION & )

PER MISSION

BELOW 5000 KM
NUMBER OF PASSES
CONTACT TIME

NUMBER OF MISSIONS

TOTAL NUMBER OF PASSES

TOTAL CONTACT TIME

GRAND TOTAL NUMBER OF PASSES
GRAND TOTAL CONTACT TIME (IN MINUTES)

Option 1	Option 2	Option 3			
		Initial	Final		
31 74	31 74	31 74	31		
74	74	[ 74 ]	74		
32	45	10	48		
992	1395	310	1488		
2368	3330	740	3552		
·					
6614	6554	3896	6937		
24411	32757	14712	36513		
		. ,	·		

### 9 GUIDANCE UPDATE ANALYSIS

Analyses of the Guidance Navigation and Control (GNC) subsystem were made to determine placement accuracies at synchronous altitude. The analyses included the effects of the navigation uncertainties of the ground tracking system and the guidance errors accumulated during each of the main engine burns.

The ground tracking accuracy was analyzed by Aerospace Corporation using a digital computer simulation based upon the current range tracking accuracy of the STDN and SGLS equipment. The simulations established a need for four ground contacts in low earth orbit to determine navigation parameters of sufficient accuracy to accomplish the synchronous deployment mission. After four station contacts in low earth orbit, the navigation uncertainties were as follows:

	Postion	Velocity
•	(ft)	(ft/sec)
Radial	610	3.0
In Track	3040	0.6
Cross Track	610	0.6

An analysis of the ground station coverage was made to determine the number of possible contacts in the low orbit portion of the synchronous mission. The following stations were assumed in the analysis.

MIL - Mila	ACN -	Ascension
TAN - Tanamarine	BUR -	Johannesburg
HAW - Hawaii	QÜ.L —	Quito
GDS - Goldstone	AGO -	Santiago
ROS - Rosman	GWM =	Guam

BDA - Bermuda

The results are summarized in Figure 9-1 and Table 9-1. The time scale origin is at Shuttle lift off. Based on the navigation analysis, the earliest opportunity for the phasing orbit burn is approximately one hour and forty minutes after launch. Depending on the longitude of the payload deployment, the first burn can be as late as 11 hours and 5 minutes.

Availability of tracking stations for the transynchronous orbit was also investigated. For this analysis only the five stations were utilized:

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Table 9-1 (Page 1 of 2)
TRACKING STATION COVERAGE
(for 28.5° parking orbit)

Acquisition of	of		
Signal*	Signal*	Δt	Station
HR:MIN	HR: MIN	MIN	
0:00	0: 2.84	2.84	MIL
0:32.15	0:36.82	4.660	TAN
1:13.31	1:17.25	3.943	HAW
1:23.82	1:27.15	3.331	GDS
1:30.96	1:36.04	5.079	MIL
1:31.25	1:34.06	2.810	ROS
1:35.69	1:37.65	1.954	BDA
1:49.68	1:55.67	5.990	ACN
2: 0.93	2: 7.56	6.642	BUR
2: 5.89	2:11.10	5.216	TAN
2:47.10	2:51.90	4.800	HAW
2:57.31	3: 0.89	3.585	GDS
3: 5.51	3: 9.00	3.496	MIL
3:39.16	3:44.92	5.751	ACN
3:50.30	3:57.06	6.755	BUR
3:56.15	4: O.80	4.650	TAN
4:22.30	4:28.96	6.658	GWM
4:45.06	4:51.07	6.011	HAW
4:55.61	4:59.56	3.951	GDS
5: 7.40	5:1 <b>2.7</b> 5	5.552	QUI
5:34.47	5:41.18	6.712	BUR
5:39.90	5:45.91	6.006	TAN
6:42.33	6:48.70	6.367	QUI
7: 9.88	7:16.65	6.769	BUR
7:15.02	7:21.77	6.750	TAN
7:56.28	8: 3.05	6.774	HAW
8:25.24	8:27.94	2.703	AGO
9:58.56	10: 4.52	5.957	AGO

Table 9-1 (Page 2 of 2)
TRACKING STATION COVERAGE

(for 28.50 parking orbit)

Station	Δt	Loss of Signal*	Acquisition of Signal*
•	MIN	HR:MIN	HR: MIN
GWM	2.079	10:57.07	10:56.99
, AGO	6.381	11:49.85	11:33.47
ACN	6.082	11:54.56	11:48.48
GWM	6.292	12:36.95	12:30.66
AGO	5.713	13:14.38	13: 8.66
ACN	6.055	13:29.65	13:23.60

<sup>\*</sup>Based on minimum look angle of  $5^{\circ}$ 

COOK - Vandenberg

GWM - Guam

BOSS - New Hampshire

IOS - Indian Ocean

HULA - Hawaii

Because the destination to geosynchronous altitude can be arbitrary, arrival longitude was made a variable parameter. Figures 9-2 through 9-6 show the tracking coverage for each of the five stations. Figure 9-7 shows the total coverage for all stations. These data were generated from an MDAC computer program called Trajectory Simulation Manual Program AD77. This program was originally developed as an analysis aid for SaturnSS-IVB stage preflight and post flight simulations. Results show that complete coverage is available after about 75 min. during the ascent. With continuous coverage available after 75 minutes, the navigation accuracy is as follows:

	Position	Velocity
	(ft)	(ft/sec)
Radial	533	.189
In Track	3261	.130
Cross Track	15245	1.250

The guidance error sources are summarized in Table .9-2 and are based upon present strapdown hardware technology. The gyro errors are based upon uncalibrated drift rates which can be reduced considerably if the gyro is calibrated prior to the Tug launch. This error analysis is also based upon utilization of the star trackers for an attitude update prior to each main engine burn. The placement accuracy sensitivities to these error sources are summarized in Table .9-3 which indicates that accelerometers are the major source of error. The errors are based upon uncorrected targeting data.

Table 9-4 summarized the total placement accuracy for both the uncorrected and corrected cases. The corrected placement accuracy is based upon retargeting of the final insertion burn using the navigation update during the transynchronous orbit. Both cases are well within the specified placement accuracies.

Table 9-2

GNC PLACEMENT ACCURACY

GUIDANCE ERROR SOURCES (30)

GYRO ERRORS

BIAS DRIFT

G-SENSITIVE DRIFT

G2-SENSITIVE DRIFT

. ALIGNMENT

. READ OUT ACCURACY AND LINEARITY

II ACCELEROMETERS

1. SCALE FACTOR

. LINEARITY

. ALIGNMENT

III STAR TRACKER

1. INST. ACCURACY

2. ALIGNMENT

STRAPDOWN

0.45 DEG/HR 0.06 DEG/HR 0.06 DEG/HR/G<sup>2</sup>

60 SEC 300 PPM (.03%)

•

PENDULUM TYPE

180 PPM (.018%) 90 PPM (.009%)

SS 53

STRAPDOWN

45 SEC

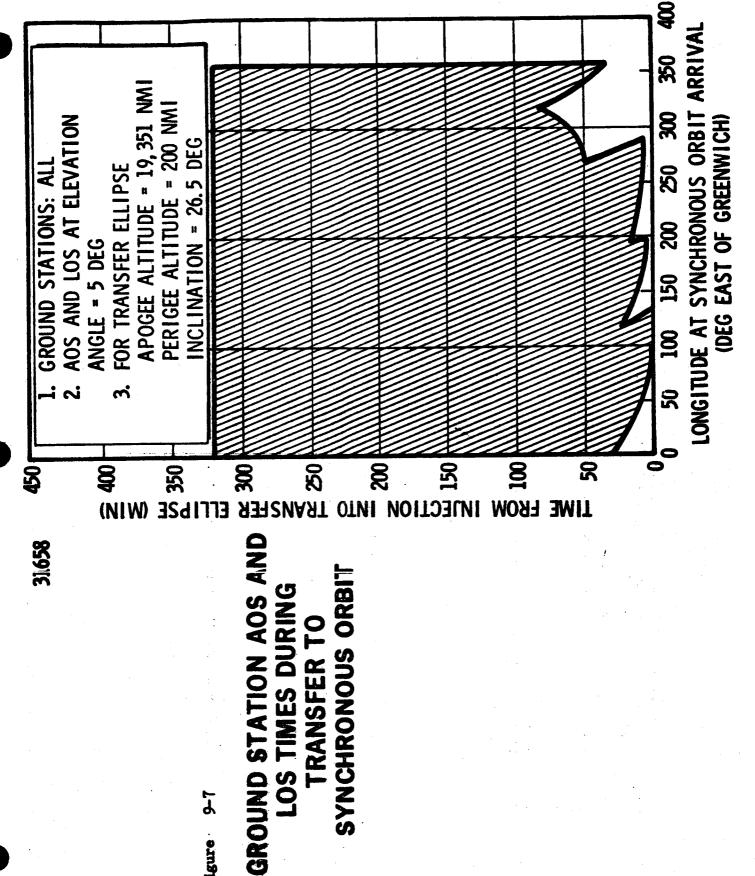
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Table-9-3
GNC PLACEMENT ACCURACY
GUIDANCE ERROR SENSITIVITIES (30)

	••	N	UNCORRECTED	
MAJOR ERROR SOURCES	HI	IN TRACK	CROSS RANGE	RADIUS
GYRO DRIFT		9.5	6.4	3.1
GYRO READOUT		1.0	4.0	0.2
ACCELEROMETER READOUT		26.3	13.8	11.4
ALIGNMENT	:	3.6	2.0	1.3
		1		

Table 9-4
GNC PLACEMENT ACCURACY
SYNCHRONOUS DEPLOYMENT ACCURACIES (NMI) (30)

UNCOR	UNCORRECTED	IN TRACK	CROSS RANGE	RADIUS	RSS
	o GUIDANCE ERRORS	28.2	14.8	11.9	34.6
0	NAVIGATION ERRORS	13.2	4.9	18.3	23.9
0	RSS	31.1	16.8	21.8	41.5
CORRECTED	CTED				
ó	o GUIDANCE ERRORS	Neg	Neg	Neg	Neg
	NAVIGATION ERRORS	0.5	2.5	0.1	2.55
•	RSS	0.5	2.5	0.1	2.55



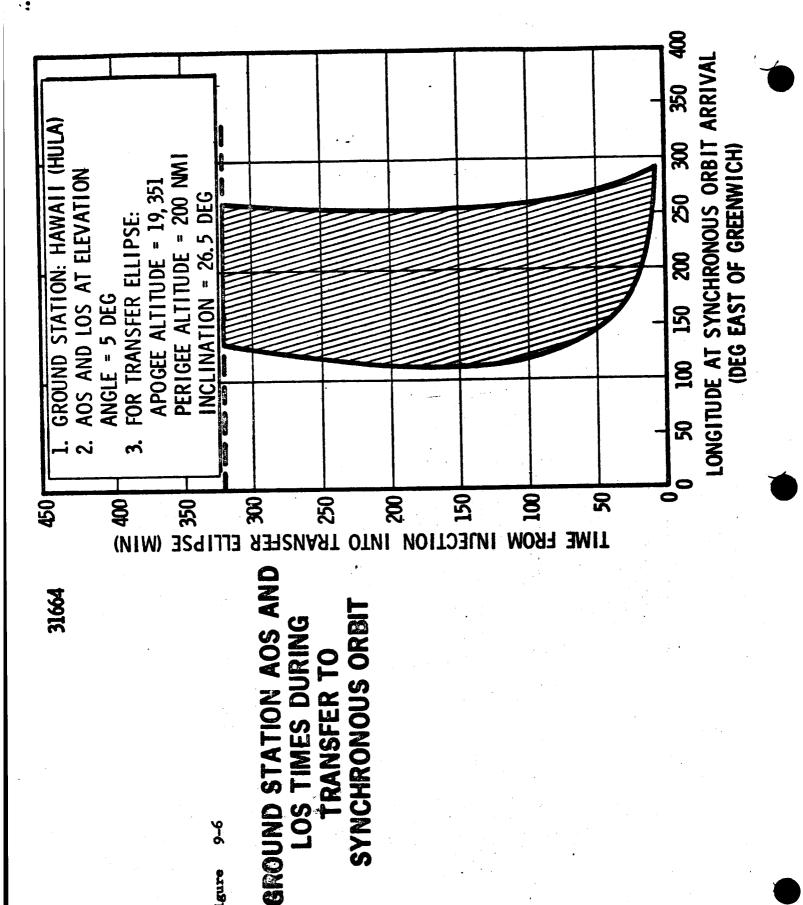
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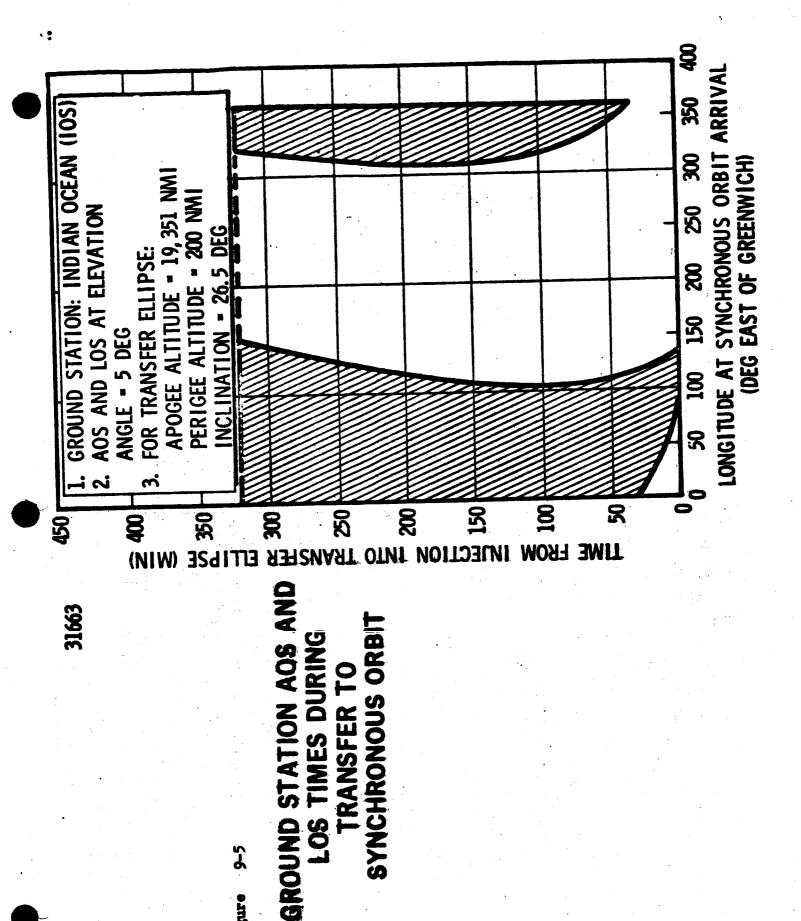
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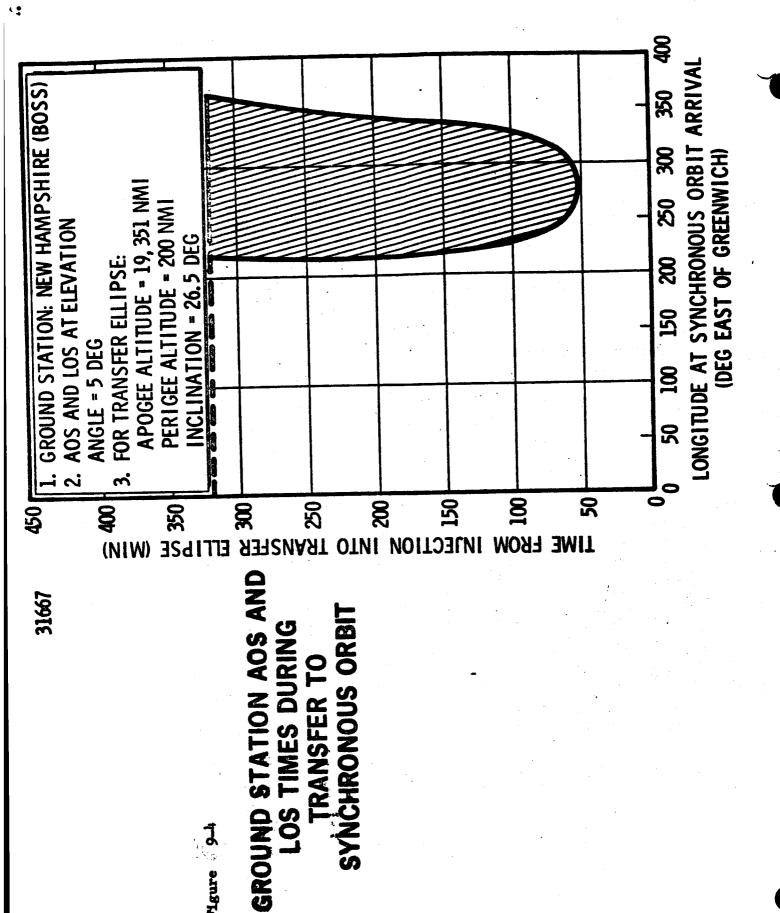
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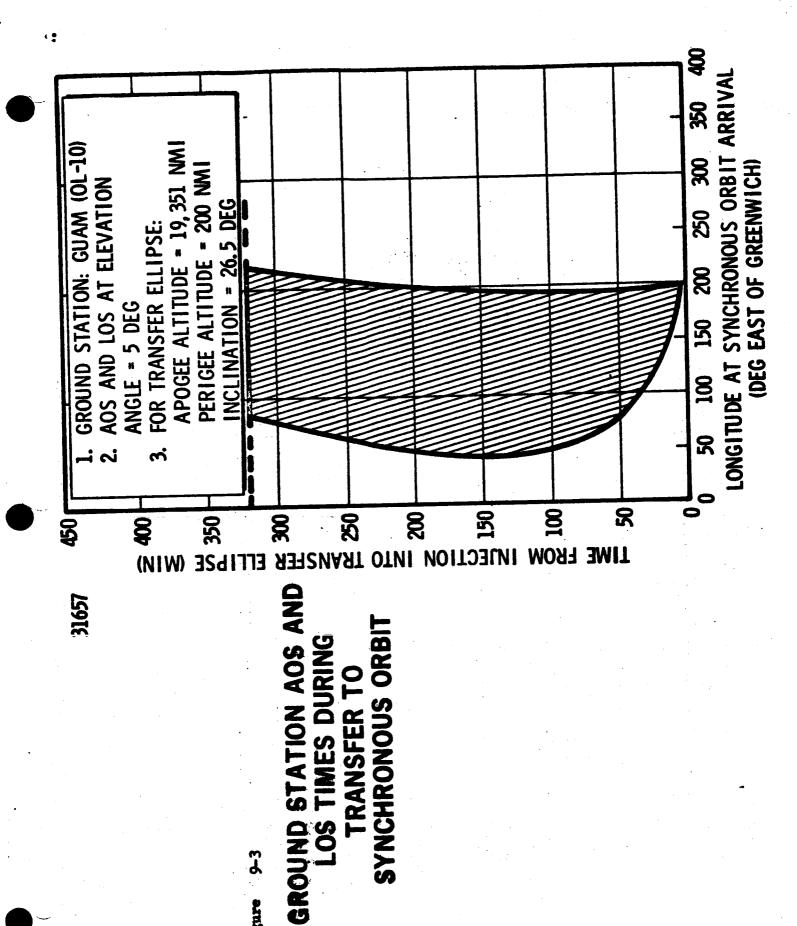


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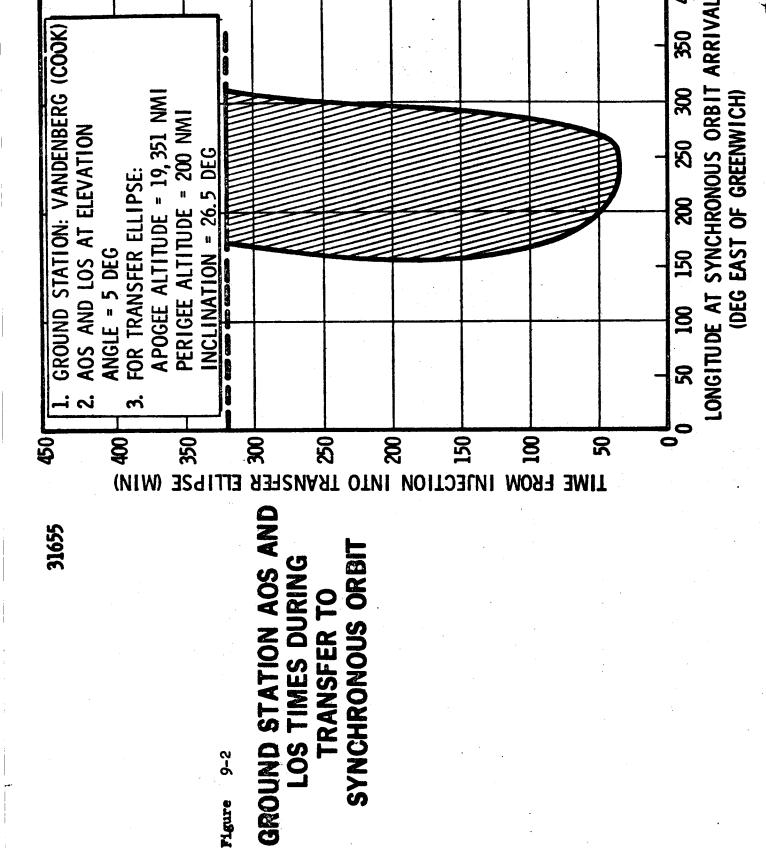
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Figure

#### 10 RENDEZVOUS AND DOCKING

#### 10.1 Rendezvous

Baseline rendezvous and docking operations for option 3F are initiated immediately following the injection burn into the target vehicle orbit. Targeting conditions for this burn are defined by vehicle placement accuracies and rendezvous sensor capabilities. Specifically, the targeting point must be chosen so as not to exceed the sensor maximum range and maximum scan capabilities for a given placement accuracy. This relationship between accuracy, targeting, and sensor acquisition is shown in Figure 10-1. The rendezvous sensor specified for these options is body fixed scanning laser radar with a maximum range capability of 100 nmi and a scan field of view of +15°. The placement accuracy for both options is +10 nmi (30). Referring to Figure 10-1 meeting the +15° FOV requirements results in a targeting range of 50 nmi and a maximum range of 60 nmi., (Points A) which conforms to sensor capabilities. These range values may then be referred to Figure 10-2 which shows the rendezvous time/energy trade. For a 6 hour rendezvous interval (chosen to minimize out of plane correction requirements) the rendezvous  $\Delta V$ required is between 26 and 39 ft/sec.

By relaxing the  $\pm 15^{\circ}$  acquisition scan angle condition rendezvous energy requirement may be reduced. Since the sensor is body fixed this requires maneuvering the vehicle to increase the effective scan FOV. As indicated in rigure 10-1, increasing this value to  $\pm 45^{\circ}$  results in an energy penalty of 2.3 ft/sec (equivalent  $\Delta V$ ) and a time penalty of 16.5 min and gives a nominal range of 25 mi and a maximum range of 35 mi (Points B). From Figure 10-2 this results in a rendezvous  $\Delta V$  range of 12-21 ft/sec or a net nominal V reduction of 13.7 ft/sec.

#### Docking

The docking phase of the operation begins after braking the gross rendezvous velocity and at a range where docking port orientation can be detected. Following this detection a small (~2 FPS) axial closing velocity is commanded. Subsequently a lateral circumnavigation velocity is commanded to maneuver the vehicle to the desired position along the extended docking port axis. The exact

ranges at the start and finish of this maneuver are not critical but there is significant relationship between them. The initial range must be large enough that a range of 500-1000 ft is required. Figure 10-3 shows a simulation of the small lateral velocity input. Otherwise the sloshing excitation caused by lateral acceleration may jeopardize controllability. Simulation results indicate that a range of 500-1000 ft is required. Figure 10-3 shows a simulation of the terminal phase of such a maneuver.

Once translational and rotational alignment with the docking axis has been attained final closure to contact is initiated. Nominal closure rate will be 1 fps and the vehicle attitude and translational position measured by the sensor and nulled about the docking axis. Simulation studies (including sloshing effects) have shown that this maneuver may be controlled within the following limits.

Axial Velocity ±.25 FPS

Rotation ±.20 deg

Translational Position ±.3 ft

As the Tug approaches the target there will be a minimum range condition at which closed loop tracking and homing ceases. From this point to contact the vehicle is inertially controlled based on the last measured closing conditions. Contact error conditions may then be determined based on the control accuracies given above, sensor accuracy, and the accuracy of the terminal inertial closure. The error values as defined in Volume 5 are:

Sensor Angular Measurement .02 deg

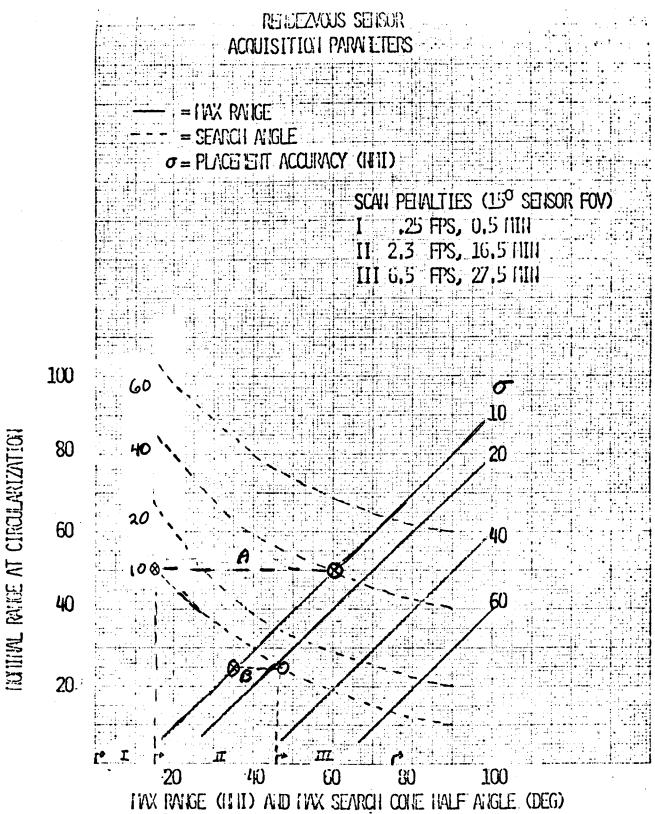
Gyro Drift .2 deg/hr

Accelerometer Null Error 10µg

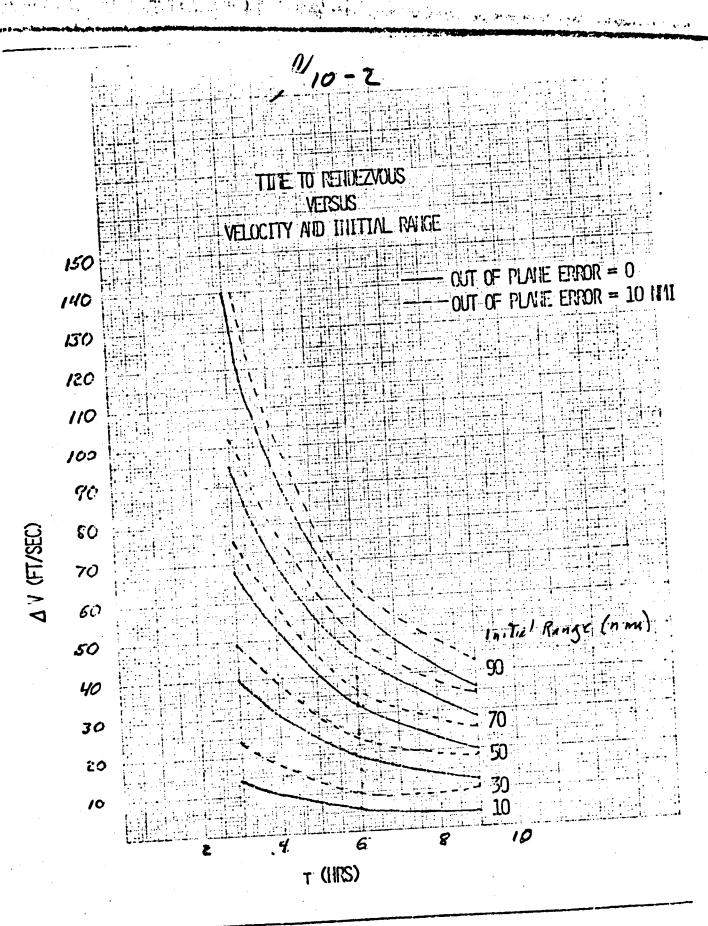
Sensor-IMU Alignment .l. deg

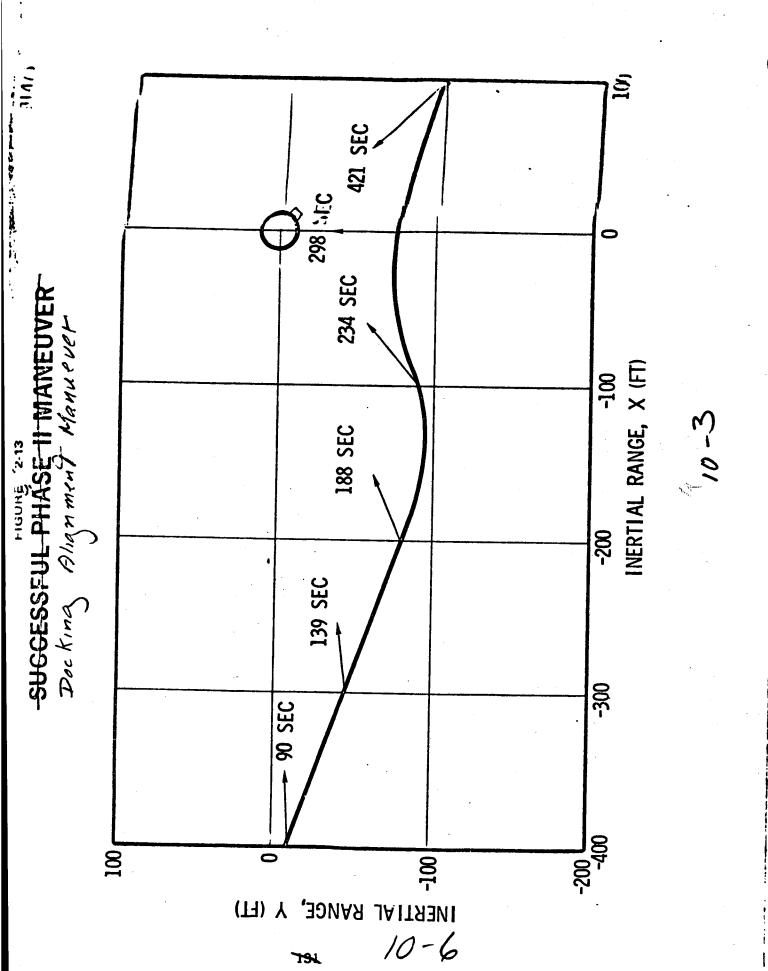
The resultant contact error values are shown in Figure 10-4 as a function of loss of track range. For the sensor alone the minimum range capability is 5 ft giving a contact error of 5.7 in. However, geometric viewing constraint may increase this minimum range value. For example, with the sensor on the

periphery of the Tug and a requirement to view the center of the target (probable for spinning targets) the minimum viewing range is 26 ft. Referring to Figure 10-4 this increases the contact error to 6.3 ft. However, the docking mechanism will tolerate errors of up to 10 in so that the minimum viewing range requirement indicated is 46 ft which seems achievable for any target geometry viewing conditions.



10-4





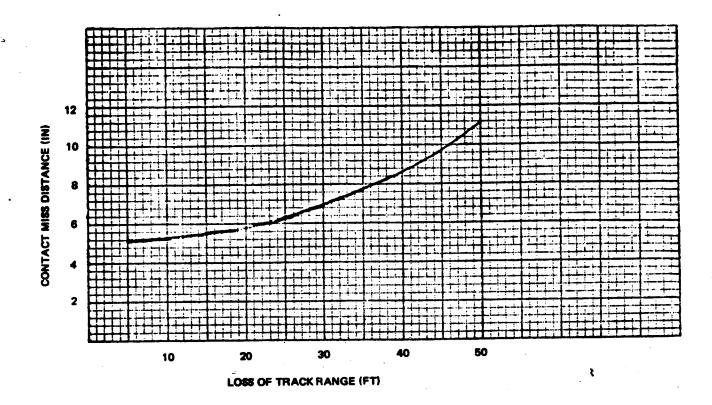


Figure 10-4. Minimum Track Range vs Docking Contact Miss

GROUND AND LAUNCH OPERATIONS

#### 11.1 INTRODUCTION

The results of the ground and launch operations task include the detailed definition of all ground and launch operations activities, equipment, manpower and schedules at both the Eastern Test Range (KSC) and Western Test Range (VAFB) which are required to support both NASA and DOD Tub missions.

The overall study/program objectives which related to the ground and launch operations task are to

- 1) Low cost, development and operational, shall be a prime objective in the attainment of the Space Tug capability.
- 2) The Tug shall be fully reusable with a minimum life of 20 missions with a design goal of 100 missions.
- 3) The mission success reliability goal for the Tug shall be 0.97 minimum for all mission phases.
- 4) The Space Tug will be designed to be returned to earth in the Shuttle and be reused; reusability with minimized maintenance/ground turnaround cost is a design objective.
- 5) The Tug shall achieve resonable turn-around times and effective mission cost by reducing as much as possible, maintenance and inspection of systems, resulting in minimum subsystem replacements between flights.

The methodology of the ground and launch operations development for the cryogenic Tug basically consists of a ten step process. Each process step is described below and illustrated in Figure 1.

GROUND & LAUNCH OPERATIONS METHODOLOGY

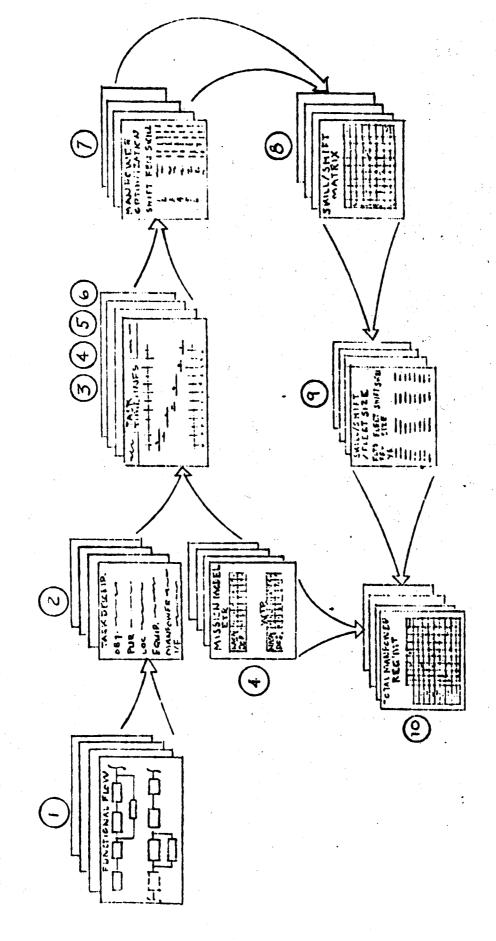


Figure 1

### STEP 1: FUNCTIONAL FLOWS

For each Tug vehicle configuration option, top level functional flow diagrams were developed utilizing data and groundrules presented in the April 1973 data package to reflect the operational requirements of each Tug option for the following items:

Flight Requirements (NASA/DOD)

- o ETR launches
- o WTR launches

Flight Composition

- o Tug (Basic)
- o Tub with Kick Stage

### STEP 2: TASK DESCRIPTION SHEETS

As a prerequisite to the development of timelines and manloading, a task description sheet was constructed for each function identified in the functional flow diagrams of Step 1. These sheets were based on the guidelines and requirements contained in the April 1973 data package as well as MDAC experience in performing similar tasks on the SIV, SIVB, Thor, Thor Delta, and Skylab programs. The title, objective, purpose, location, required equipment, manpower and interface requirements for each functional task were specified on these sheets.

#### STEP 3: SUBTASK DEFINITION

Individual subtasks and their respective manpower allocation required to accomplish each functional task were defined utilizing the task description sheets of Step 2. Timelines were then developed to determine the overall time required for each functional task. These sheets were coordinated (and modified as necessary) with company engineers having appropriate checkout, maintenance and repair experience to insure the reasonableness of the time estimates and adequacy of the equipment defined.

#### STEP 4: MISSION MODEL ANALYSIS

The mission model for each Tug vehicle configuration option was analyzed

for each launch site with regard to number of launches, user (NASA and DOD), flight composition, and mission type (deployment, round trip, etc.) The predominate Tug mission was then selected for detailed analysis and development of task timelines and sequences, and ground and launch operations manning requirements.

### STEP 5: TASK TIMELINES AND SEQUENCE DEVELOPMENT

Based on the predominate Tug mission selected for each Tug vehicle configuration option in Step 4, the appropriate functional task timelines developed in Step 3 were assembled on a sequential hour by hour basis in a manner consistent with the functional flows for each respective Tug option.

### STEP 6: TURNAROUND TIMES

Tug turnaround times were determined and top-level operational bar-chart flows were developed for each Tug configuration option based on the assembled timelines of Step 5. Statistical analyses of unscheduled maintenance requirements were included to provide adequate time for contingencies. By this means, the probability of meeting the turnaround time was established as .985.

### STEP 7: SKILL PER SHIFT DETERMINATION

The task timeliness of Step 5 were evaluated on a task per flight basis and appropriate manpower skill requirements were optimized utilizing skill sharing techniques where possible to assure maximum utilization of individual workers.

# STEP 8: MAXIMUM vs. MANDATORY SKILL BREAKDOWN

A skill per shift matrix was developed for each Tug vehicle configuration option utilizing the data derived in Step 7 in order to determine the maximum skill breakdown requirements and the mandatory skill breakdown

requirements during those shifts whose operations are constrained by the Orbiter ground processing schedule.

# STEP 9: MANPOWER vs. FLEET SIZE DETERMINATION

Based on the required on-orbit time and the turnaround time derived in Step 6 for each Tug option, liftoff to liftoff times were determined and the active Tug fleet size for any required launch rate was derived. Manpower levels for each required skill were then assigned on a per-shift basis accordingly.

#### STEP 10:

Utilizing the data generated in Step 9 and the number of required launches per year as specified in the traffic model for each Tug option, a total manpower per skill per shift per year matrix was developed.

The ground operations plan developed for each Tug vehicle configuration option provides the necessary supportive elements and associated data necessary to accomplish the study/program objectives and includes the following with pertinent results summarized in Figure 2.

- 1. Ground operations cost data for each WBS element
- 2. Manning requirements (skill categories, crew sizes by year based on launch rate for both ETR and WTR)
- 3. Active Tug Fleet size
- 4. Total program fleet size
- 5. Impact to Ground Operations in each applicable area for a two-year IOC delay for each Tug option
- 6. Operations constrained by the Orbiter
- 7. Ground turnaround operations description and timelines based on functional flow diagrams
- 8. Task descriptions for each Tug option
- 9. New, existing, or modified facilities and respective costs

- 10. GSE descriptions (type, amount, location, cost, etc.)
- 11. Maintenance/Refurbishment/Checkout impact on turnaround cycle
- 12. Spares planning

		•				CR 143
	STUDY TASK	OPTION 1	OPTION 2	OPTION 31	OPTION 3F	OPTION 3 COMPOSITE
,11	GROUND OPS.	ETR: \$64,06 M WTR: \$21,36 M	ETR: \$53.07 M WTR: \$22.86 M	ETR: 839.19 M WTR: \$25.6 M	ETR: \$57.84 M WTP: \$7.93 M	ETR: \$97.03 M WTR: \$33.63 M
2)	MANNING REQ'MTS	PEAK YEAR MANNING ETR: 159 WTR: 89	PEAK YEAR MANNING ETR: 260 WTR: 126	PEAK YEAR MANNING ETR: 168 WTR: 119	PEAK YEAR MANNING ETR: 245 WTR: 90	PEAK YEAR MANNING ETR: 280 WTR: 181
3)	ACTIVE TUG FLEET SIZE	ETR: 3 MAX. 1 MIN, WTR: 1	ETR: 3 MAX, 2 MIN. WTR: 1	ETR: 3 MAX, 1 MIN. WTR: 1	ETR: 4 MAX, 2 MIN. WTR: 1	ETR: 4 MAX. 1 MIN. WTR: 1
4)	TOTAL PROGRAM TUG FLEET SIZE	ETR: 8 WTR: 2	ETR: 7 WTR: 2	ETR: 2 WTR: 2	ETR: 6 WTR: 2	ETR: 8 WTR: 2
5)	2 YEAR IOC IMPACT	184 MAN-YR REDUCTION AT ETR	431 MAN-YR INCREASE AT ETR 190 MAN-YR INCREASE AT WTR	243 MAN-YR REDUCTION AT ETR	NO EFFECT	243 MAN-YR REDUCTION AT ETR
6)	OPS. CONSTRAINED SY ORBITER	LANDING TO LANDING + 21 HRS L/O - 144 HRS TO L/O	LANDING TO LANDING + 21 HRS L/O-144 HRS TO L/O	LANDING TO LANDING + 21 HRS L/O - 144 HRS TO L/O	LANDING TO LANDING + 21 HRS L / O - 144 HRS TO L / O	LANDING TO LANDING + 21 HRS L / O - 144 HRS TO L / O
7)	GROUND TURNAROUND TIME (HRS)	ETR: 301 NASA 309 DOD WTR: 308 NASA 308 DOD	ETR: 328 NASA 341 DOD WTR: 328 NASH 328 DOD	ETR: 308 NASA 319 DOD WTR: 308 NASA 309 DOD	ETR: 328 NASA 341 DOD WTR: 324 NASH 324 DOD	ETR: 328 NASA 341 DOD WTR: 324 NASA 324 DOD
8)	TABK DESCRIPTION DEVELOPMENT	55 FUNCTIONAL TASKS DEFINED	SB FUNCTIONAL TASKS DEFINED	86 FUNCTIONAL TARKS DEFINED	58 FUNCTIONAL TASKS DEFINED	SE FUNCTIONAL TASKS DEFINED
9)	FACILITIES RECOMTS DEFINITION	REQUIRES A NEW PAYLOAD PROCESSING FACILITY AT ETR & WTR	REQUIRES A NEW PAYLOAD PROCESSING FÁCILITY AT ETR & WTR	REQUIRES A NEW PAYLOAD PROCESSING FACILITY AT ETR & WTR	REQUIRES A NEW PAYLOAD PROCESSING FACILITY AT ETR & WTR	REQUIRES A NEW PAYLOAD PROCESSING FACILITY AT ETR & WTR
10)	GSE DESCRIPTION	78 TYPES OF GOE EQUIP. REQUIRED	82 TYPES OF GBE EQUIP. REQUIRED	77 TYPES OF GSE EQUIP. REQUIRED	83 TYPES OF GSE EQUIP. REQUIRED	83 TYPES OF GSE EQUIP. REQUIRED
- 11	IAINT / REFURS / MECKOUT MPACT ON URNAROUND	MAINT / REFURE / CHECKOUT REQUIRES 75 HRS	MAINT / REFURS / CHECKOUT REQUIRES 75 HRS	MAINT / REFURB / CHECKOUT REQUIRES 75 HRS	MAINT / REFURS / CHECKOUT REQUIRES 75 HRS	MAINT / REFURE / CHECKOUT REQUIRES 75 HRS

Figure 11-2. Ground and Launch Operations Summary

#### II 2 Groundrules and Assumptions

The groundrules and assumptions which influence the development of the ground and launch operations planning are summarized as follows.

#### 11.2.1 General

#### Objectives

- Low cost, development and operational, shall be a prime objective in the attainment of the Space Tug capability. (Data Package)
- The Tug shall achieve reasonable turn-around times and effective mission cost by reducing as much as possible maintenance and inspection of systems, resulting in minimum subsystem replacements between flights. (Data Package)

### Facilities

- The Tug shall be capable of being serviced by the standard STS environmental, power, and fluids service facilities. Unique support requirements shall be provided by the Tug contractor. (Data Package)
- Facilities are required at WTR and KSC to support pre-flight and post-flight processing of the Tug. The facilities shall provide standard services, e.g., power, fluid, and environmental control.

#### II.2.2 Ground Systems

#### Ground Support Equipment

- The need for specialized post-flight servicing equipment shall be minimized. (Data Package)
- Reconfiguration on the (Orbiter) access panels will be charged to the Tug will the unique AGE required for the checkout or test procedures. (Data Fackage)

### **Checkout**

- The Tug shall utilize the automatic checkout AGE for pre-flight and postflight checkout and test procedures. (Data Package)
- When installed in the orbiter cargo bay on the launch pad, Tug access to the automatic checkout system shall be via the standard Tug to orbiter interfaces. (Data Package)

- Unique Tug checkout or test requirements will be supported from the Mobile Payload Service Tower through orbiter interface panels. (Data Package)
- The Tug shall also be capable of interfacing with a secure SGLS compatible communications system when secure data transmissions are required to support Tug processing procedures. (Data Package)

### Receipt

11.2.3

- o The Landing Facility will be utilized to screent initial.

  delivery of the Tug at the launch site wim Logistic aircraft.

  (Data Package)
- o The Landing Facility will provide for post-flight recovery of the Tug via the Orbiter vehicle. (Data Fackage)
- New Tugs will be delivered to the Launch site by sir. (Data Package)
- o The aircraft will be off-loaded with contractor furnished transportation and handling equipment. (Data: Package)
- The Tug off-loading from aircraft will be accomplished by a launch site crew who will remove the wehicle from the aircraft and deliver it to the PFF at WTR or the Tug Processing.

  Facility at KSC. (Data Package)
- o Any specialized shipping equipment will be removed following receipt (at the PPF or TPF) and returned to the contractor.

  (Data Package)
- o A new Tug will be subjected to a wisual and functional inspection for shipping damage. (Data Package)

### Storage

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At the completion of the initial receiving inspection operation or the maintenance cycle, the Tug will be prepared for storage in an operational condition if not scheduled for a mission. (Data Package)

#### Refurbishment

- o At WTR, the DOD will perform postflight maintenance and refurbishment operations for both DOD and NASA Tugs in a dedicated DOD payload processing facility. (Data Package)
- At KSC, NASA will perform postflight maintenance and refurbishment for both DOD and NASA Tugs in the NASA Tug

  Processing Facility. (Data Package)
- At WTR, the Payload Processing Facility supports the receipt, storage, refurbishment and pre-flight processing and checkout of the Tug, including, if required, mating and integration of the Tug with a spacecraft. (Data Package)
- At KSC, the Tug Processing Facility supports the receipt,
  storage, refurbishment and pre-flight processing and checkout
  of the Tug, including, if required, mating and integration
  of the Tug with a spacecraft. (Data Package)

- The activities will include performance of required corrective actions identified during the preceding mission and those identified during the inspection, handling, and service activities of the turnaround cycle. (Data Package)
- Predictable maintenance using trend analysis data derived from on-board systems will be emphasized to the maximum extent possible. (Data Package)
- Preventive maintenance actions will be systematically carried out to provide for the general care of the Tog. (Data Package)
  - Inspection
    - The Tug will be subjected to a detailed visual inspection of all accessible spaces and installations on arrival in the Tug Maintenance Facility. (Data Package)
    - Accessible Inspection will include the following:
    - a. Vehicle structure condition
    - b. Security of subsystem installation
    - c. Containment of fluids
    - d. General condition of vehicle
    - e. General cleanliness of vehicle (Data Package)

Inspection of spaces not remitly accessible, and
the non-destructive evaluation of structural and
mechanical equipment, will be completed on a
periodic basis depending on the number of missions
completed and total flight hours. (Data Fackage)

- Inspections will be performed throughout the maintenance and checkout cycle on a progressive basis to insure vehicle integrity. (Data Package)
- Preplanned preventive maintenance will be accomplished during every maintenance operation. Preventive maintenance will be scheduled for periodic accomplishment on equipment not requiring service after every flight. (Data Package)
- Unscheduled maintenance will be accomplished on an "as required" basis. (Data Package)

# Preflight Processing

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- O Refurbished DOD Tugs at KSC will be routed to a dedicated

  DOD payload processing facility for preflight processing by

  DOD personnel. (Data Package)
- Premate activities will be to establish and test the interface (mechanical, electrical, and fluid) between the Tug and the spacecraft and/or Orbiter. (Data Fackage)

The Shuttle Integration and Mating Facility will provide the capabilities to perform Tug and/or Spacecraft health checks.

New Tugs will undergo integrated systems tests prior to premate operations.

Systems containing a reported malfunction will be tested to verify and isolate the discrepancy.

When the required maintenance actions on the vehicle have been completed, all subsystems that have been entered for maintenance purposes will be individually checked out and verified.

At the completion of the maintenance and checkout procedures, the Tug will undergo integrated system tests to verify flight resiliness.

- The Tug-to-Spacecraft making will be performed in the PPF for DOD spacecraft, and in the TPF for WASA spacecraft at KSC.
- The Tug-to-Spacecraft mating will be performed in the PPF at WIR.
- Tug-to-Spacecraft mating operations are completed with interface verification and integrated system tests.
- Spacecraft cleanliness shall be maintained and verified following the mating activities.

## Installation in Orbiter (Data Package)

- Installation of payloads (Tug and/or spacecraft)
  in the Orbiter cargo bay is currently baselined to
  be accomplished in the Orbiter MCF while the Orbiter
  is in the horizontal position.
  - Installation in the vertical position using the payload changeout facilities provided at the launch pad shall be utilized for contingencies only.

1

The Orbiter MCF provides the capability for installation of the Tux or Tux/spacecraft assembly in the Orbiter cargo bay.

The electrical and mechanical mating operations are performed and interface verified through AGE/GSE and the mission operator console.

# O Storable Propellants (Data Package)

The Storable Propellant Facility provides the capability for loading storable propellants into the Tug for preflight operations.

The Storable Propellant Facility provides the capability for residual propellant removal and Tug decontamination.

# o Environment (Data Package)

The Shuttle Integration and Mating Facility will provide the capability to maintain the Orbitan cargo bay environmental condition within the requirements of the Tug and/or spacecraft.

# Servicing (Data Package)

- Facilities at the launch pad will provide the following for the Tug:
  - a. Propellant Fill and Drain
  - b. Emergency Propellant Drain

#### (Cont.)

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- c. Pressurant Fill and Vent
- d. Communications Links for Status Monitoring
- e. Subsystem Tests
- f. Integrated System Test

Storable Tug propellants and pressurents may be loaded either on the pad while the Tug is in the cargo bay or at some remote tanking facility prior to Tug/Shuttle integration

## Pad Hold (Data Package)

If a hold is required after cryogenic propellant.

loading, the propellant loading system will be configured for a replenish mode of operation.

During a hold period, selected airborne and AGE/GSE parameters will be monitored to ascertain the Tug system status.

# Backout (Data Package)

Cryogenic propellant detanking will be accomplished.

via the propellant loading system GSE.

During detanking, individual drain lines will be utilized for the Tug and Orbiter, and this will be accomplished simultaneously.

The removed payload (Tug and/or spacecraft) will be returned to the PPP or the TPF.

#### Postflight

- o Safe and Purge (Data Package)
  - At the safe and purge area, residual propellants
     are removed and the propellant tanks purged.
  - At the safe and purge area, high pressure gas systems are vented.
  - At the safe and purge area, the unexpended ordinance is disarmed.
    - Thermal control of the Tug and/or spacecraft will be maintained during safe and purge procedures.
- O Removal (Data Package)
  - of the Tug or Tug/spacecraft assembly in the Orbiter cargo bay.

For contingencies, the Mobile Payload Service Tower will support payload removal at the Daunch pad.

Security procedures will be required if a classified spacecraft is to be removed and only spacecraft processing personnel with the required security clearance will be allowed to perform this task.

# Transportation -

- Classified Spacecraft (Data Package
  - A security patrol will accompany a classified:
    spacecraft during all transportation.
    - If a classified spacecraft is to be transported, procedures will be employed to ensure physical security.
  - Cleanliness (Data Package)
    - Cleenliness will be maintained throughout preflight transfer.
      - The Tug will be enclosed in a protective cover to maintain its cleanliness during transport to the spacecraft mating area.

# Preflight Processing

#### o Installation

- Orbiter in the horizontal position. (JSC 07700)
  - The access, removal, and loading of payload items on the pad must be accomplished no later than TED hours prior to launch. (JSC 07700)

# O Checkout and Testing

- Detailed acceptance testing of each psyload subsystem is performed prior to installation.

  (JSC 07700)
  - A launch readiness checkout will be conducted: at the launch pad prior to prelaunch servicing and propellant loading. (JSC 07700)
  - Checkout of the payload for pre-launch operations
    makes use of the ground checkout equipment and the
    onboard checkout command decoder for hardwired uplink
    commands. (JSC 97700)

Conditioned air purge will be supplied to the payload bay at the launch pad, up to 30 minutes prior to propellant loading. (JSC 07700)

- a. 0 to 200 lbs/min.
- b. 45°F to 120°F within ±2°F of desired
- c. Class 100,000
- d. 0 to 43 grains/pound of air

From 30 minutes prior to propellant losding, up to liftoff, a GN<sub>2</sub> purge (for the psyload bay) will be supplied. (JSC 07700)

- a. 0 to 200 lbs/min.
- b. 45°F to 120°F, within ±2°F of desired
- c. Class 100,000
- d. 0 to 1 grain/pound of GN,

# Post-Flight Processing

The payload will normally be removed with the orbiter in the horizontal position. (JSC 07700)

# 11.2.5 WORKING GROUP GUIDELINES

# Leunch Rates

O Use a uniform launch rate in a given year. (G & L OPS PANEL)

#### Shuttle Compliance

- The Tug ground operations must be compatible with the

  Baseline KSC Space Shuttle Processing Flow. (G & L OPS PANEL)
- o The capabilities and constraints for the Space Shuttle are summarized on Figure 11.2.5-1 (G & L OPS PANEL)
- o Manloading requirements are based on work schedule
  - a. 8 hr/shift
  - b. 2 shifts/day
  - c. 5 days/week

#### Cleanliness

o It is recommended that Tug cleanliness be compatible with that provided in the Orbiter payload bay (G & L OPS PANEL)

#### Security

O Security at WTR should be treated the same as KSC.

(G & L OPS PANEL)

#### Alternate Site

Alternate sites will not be available for the Tug Program.

(Cost Panel)

FICINE 11.2.5-1

SHUTTLE CONSTRAINTS

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11.3.1 Section 6.11.3 provides a baseline ground operations plan to support the DOD-SAMSO/NASA-MSFC Option 3 Space Tug. A pre-IOC operations plan, top-level functional flows, operations sensitivities to Tug configurations, operations constrained by the Orbiter, ground turnaround operations, task descriptions, and manning requirements are provided in this plan.

The plan identifies the ground operational requirements for the Tug, including interfaces and interactions of DOD and NASA operations at ETR (KSC) and WTR (VAFB).

A two-year IOC delay within the Option 3 Space Tug program has the following effects on active Tug fleet size and total manpower requirements.

#### Active Tug Fleet Size

a) Option 3I: The active fleet size in program years 1980 and 1981 is reduced from 1 to zero at ETR.

A two-year IOC delay has no effect on the active Tug fleet size at WRT.

b) Option 3F: A two-year IOC delay has no effect on the active Tug fleet size at either ETR or WER.

#### Total Manpower Requirements:

a) Option 3I: The total manpower requirements in program years 1980 and 1981 are reduced from 75 to zero and 168 to zero people, respectively, for a net reductions of 243 man years at ETR.

A two-year IOC delay has no effect on total manpower requirements at WTR.

b) Option 3F: A two-year IOC delay has no effect on total manpower requirements at either ETR or WTR.

11.3.2.1 Activation and Verification Operations for ETR and WTR

The schedule summarizing the activation and verification operations for ETR
and WTR is presented in Figure I. This option includes reverification of both
sites for the final configuration phase of the program.

#### 11.3.2.1.1 Eastern Test Range

The activation of ETR will begin 36 months prior to the initial IOC date, 24 months prior to the initiation of the Tug Flight Test Ground Operations of the initial configuration. During the first 20 months, the site configuration will be completed and activated. In the 21st through the 24th months, the facilities and equipment will be verified utilizing the Space Tug simulator and the Shuttle/Tug Interface simulator.

The final ETR verification and certification will be completed from the 25th through the 36th months utilizing the first flight vehicle. The personnel utilized during this phase of the program will establish, revise, and finalize the procedures and plans for the operational phase of the program. These personnel will form the nucleus of the operational ground crew compliment at ETR.

Reverification of ETR for the final configuration will be completed during a twelve month period leading up to the final phase IOC date. These activities will utilize the flight articles and the existing ground crew at ETR. This approach is possible because of the minimum vehicle (and related ground) configuration differences between the initial and final program flight articles.

#### Western Test Range

The activation of WTR will begin 12 months prior to the WTR initial configuration IOC date. Personnel transferred from ETR will activate the facilities and verify the ground configuration utilizing a flight vehicle. These same personnel will review, revise, and finalize the plans and procedures for the operational phase of WTR operations. Much of the equipment utilized at WTR will be provided from the factory and ground test equipment inventory.

Reverification of WTR for the final configuration will parallel the ETR activation and verification operations. The WTR activities will utilize a flight vehicle and they will depend heavily on close coordination between ETR and WTR.

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	•					

1976 | 1981 | 1981 | 1980 | 1981 | 1982 | 1983

11-27

### Flight Tests

The first produced Tug will be equipped with special flight test 'instrumentation in support of the following objectives:

- a. Propellant settling.
- b. Propellant utilization.
- c. Propellant feedline and engine thermal conditioning.
- d. Propellant conditioning.
- e. Zero-g heat transfer.
- f. Avionics cold plate temperature stabilization.
- g. Vibration levels of selected critical installations.

Information will be obtained from this instrumentation during the first two flights flown by this Tug. The flights will carry spacecraft for orbital placement in the event NASA is the procuring agency. These flights are dedicated test flights, however, for a DOD procured program.

### Disposition of Flight Test Vehicle

Following termination of the second flight (NASA program) the flight test instrumentation will be removed and the Tug processed through a normal turnaround cycle. This Tug will then continue normal operations within the fleet. In a DOD program, data from the flight tests are a part of the total data considered by the DSARC. During this review, this Tug will continue to fly, carrying spacecraft for orbital placement, until such time as inclusion in the fleet is ordered. At this time, the instrumentation will be removed and the Tug processed through a normal turnaround cycle.

#### Supporting Timelines

Figure 11-1 and Figure 11-2 are the schedule for this flight test operation for Options 3I and 3F. Figure 11-3 depicts instrumentation removal time requirements and turnaround cycle time lines can be found in Section 11.3.6.

REPORT PREPARATION (1) DATA ANALYSIS AND EVALUATION (2 EA) FLICHT TESTS FLIGHT OPERATIONS SUPPORT (1.5) LAUNCH OPERATIONS SUPPORT (5) TURN AROUND (1 EA) 010PT 31 I VEHICLE DILIVERY FLIGHT TEST PLANNING (9)

(PHASED INITIAL AND DIRECT DEVELOPED)

FLIGHT TEST OPERATIONS

SCHEDULE (MONTHS)

Figure 11-1

FLIGHT TEST OPERATIONS SUPPORT (5)



SCHEDULE

(MONTHS)

(PHASED FINAL)

OPT 3F

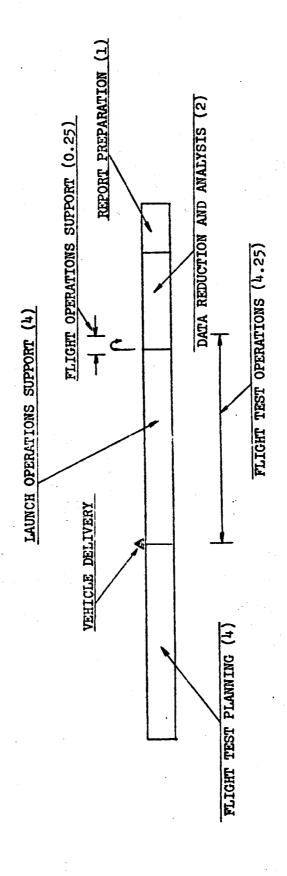


Figure 11-2

11-30

Disconnet Fligh	un anta tion	12 14 16	tcape hothical lands or Flight Test -tation	-
	Test		7	
	Options Disconned			

11.3.3 Top Level Functional Flows

Top level functional flows for ETR and WTR, options 3I and 3F, are presented in the form of summary time lines in Figures 11.3.3-1 through 11.3.3-4. The supporting flow diagrams are presented in Figure 11.3.3-5 through 11.3.3-8.

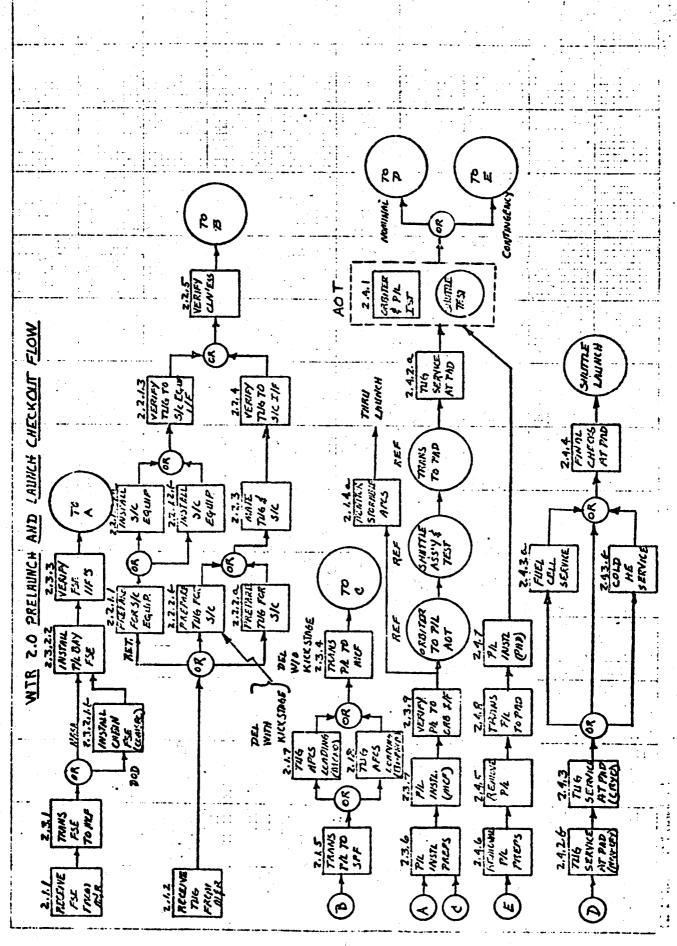
WASHUTTLE & PAYLOND OPS 306 2319 ( ) RUNNING TIME. 450 FIG 18.3-1 NASA 000 MILLIO 000 ▲ DOD LAUNCH (319) A NASA LAUNCH (306) 8 TAYLOAD AND SHUTTLE MATE (183/196) TUG MAINTENANCE AND CHECKOUT (128/141) ETR TUG TURNAROUND FLOW / OPTION NO. 3I TLIGAPCS SAFING AT STORABLE PROPELLANT FACILITY (52) 350 350 THE ARCS SERVICE AT SPF (160/173) TING AND SPACECRAFT MATE (143/156) 38 300 TESE ORBITER MATE (167) FSE ORBITER MATE (160) FSE MAINTENANCE (146) 150 200 250 INDERING TIME IN HOURS THE AND SPACECRAFT DEMATE (59/68) 250 SHUTTLE TRANSFER TO MICF AND PREPS (21.0) TUG CRYOGENIC SAFING AT SAFING AREA (14.0) PAYLOAD RECOVERY AT MCF (29.0) 200 SHUTTLE AVAILABLE AT SAFING AKEA (4.0) TRANSFER FSE TO PPF (36) TRANSFER FSETO TPF (44) 500 1) ASSUMES NOMINAL MISSION ESE RECOVERY (30) 8 SHUTTLE LANDING

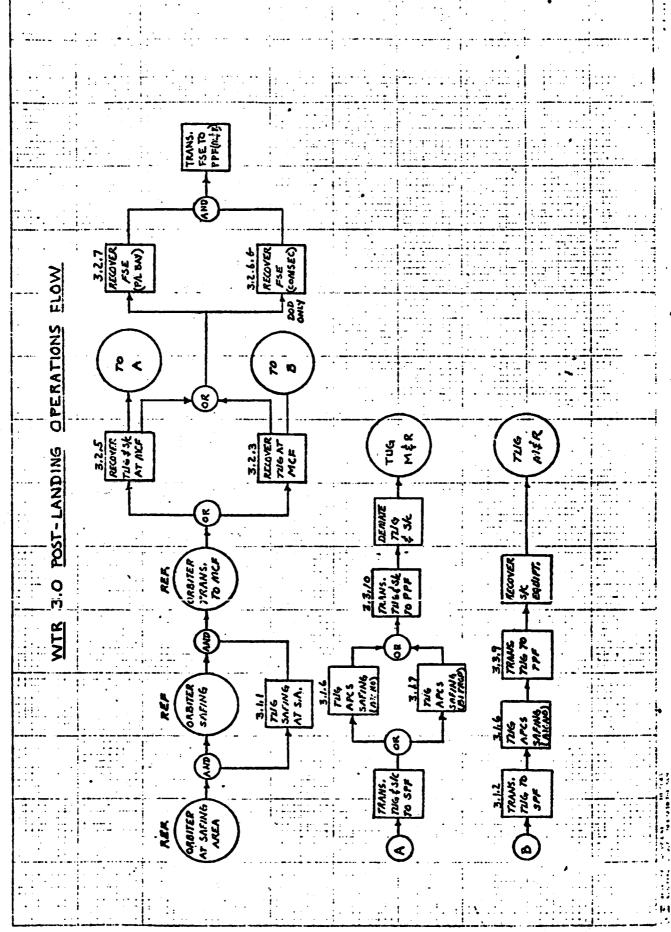
FIG 11.3.3-2 S SHUTTE & PANCADOPS. M DOD LAUNCH (328) RUNNING TIM 100 8 ETR TUG TURNARCHND FLOW OPTION NO. 3F PAYLOAD AND SHIFTLE MATE(205/218) A NASA LAUNCH NASA COCT EXTEN TILG MAINTENANCE AND CHECKOUT (142/155) 950 TING APCS SERVKE AT SPF (182/195) THE AND SPACECRAFT MATE (157/170) | THE ARES SAFING AT STORABLE PROPELLANT FACILITY (59.0) 000 300 TEEORBITER MATE (192) ESE ORBITEK MATE (11) FSE MINTENANCE(168) WORNING TIME IN HOURS 250 2 20 TUE AND SPACECRAFT DEMATE (61/76) TUG CRYOGENIC SAFING AT SAFING AREA (14.0) SHUTTLE TRANSFER TO MCF AND PREPS (21.0) 200 28 PAYLOAD RECOVERY AT INCF (29.0) SHUTTLE AVAILABLE AT SAFING AREA (4.0) MITANSFER FSE TO PPF (88) TRANSFER FSE TOTPF (44) 50 1) ASSUMES NONINALMISSION श्र TESE RECOVERY (30) 8 SHUTTE LANDING 20 11-34

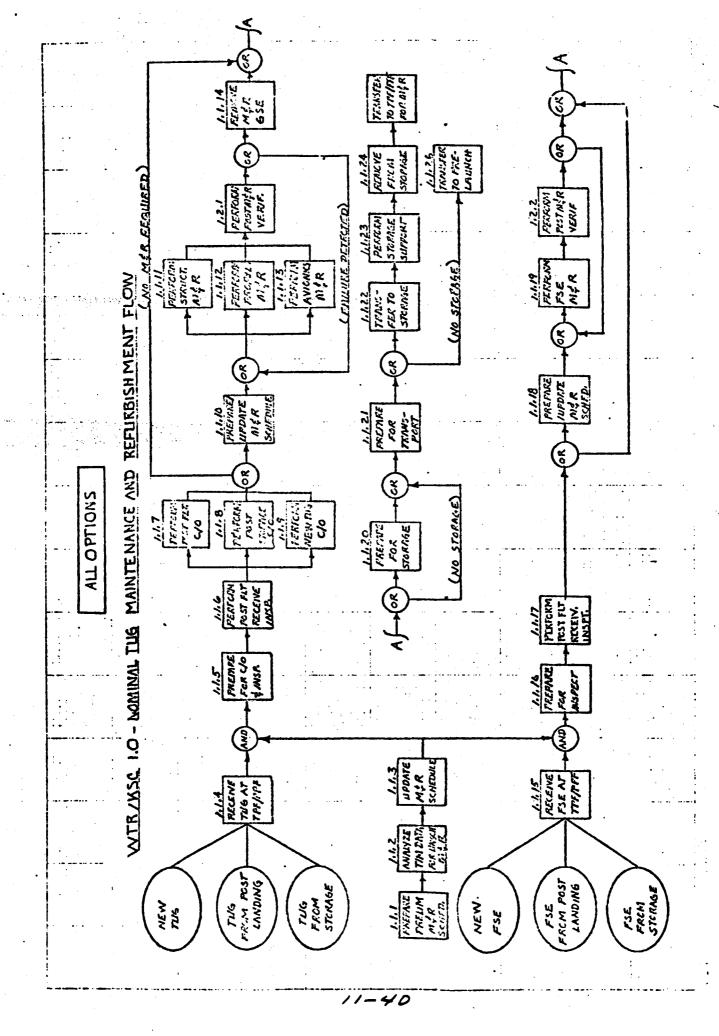
WIR THE THRINKOWND FLOW / OPTION NO. 3 I FIG 18.3-3	SEP   100   150	NOTES:  NOTES:
	o	LOX EOX

NO. 3F FIG 11.3.3-4	36.0) (61.0) (75.0) (75.0)  TE(200.0)  SHUTTLE FRYICAD OPS.  SHUTTLE LAUNCH (\$7.0)	350 400 450	MASA \$ DOD
WTR TUG TURNAROUND FLOW/OPTION (ROUND TRIP)	SHUTTLE LANDING    SHUTTLE LANDING    SHUTTLE LANDING    SHUTTLE TRANSFER AT SAFING AREA(4.0)   TUG CRYOGENIC SAFING AT SAFING AREA(4.0)   PAYLOAD RELO VERY AT INCF (29.0)   TUG AND SPACECRAFT DEMATE (6.70)   TUG AND SPACECRAFT DEMATE (6.70)   TUG AND SPACECRAFT DEMATE (6.70)   TUG AND SPACECRAFT DEMATE (9.1.0)   TUG AND SPACECRAFT MATE (15.0)   TUG AND SPACECRAFT MATE (17.0)   TRANSFER FSE TO FPF (3.0)   TRANSFER FSE TO FPF (3.0)   TRANSFER FSE TO FPF (3.0)	0 50 100 150 200 250 300 working time in holdes	NOTES;  U ASSUMES NOMINAL MISSION

FIG 11.3.3-5







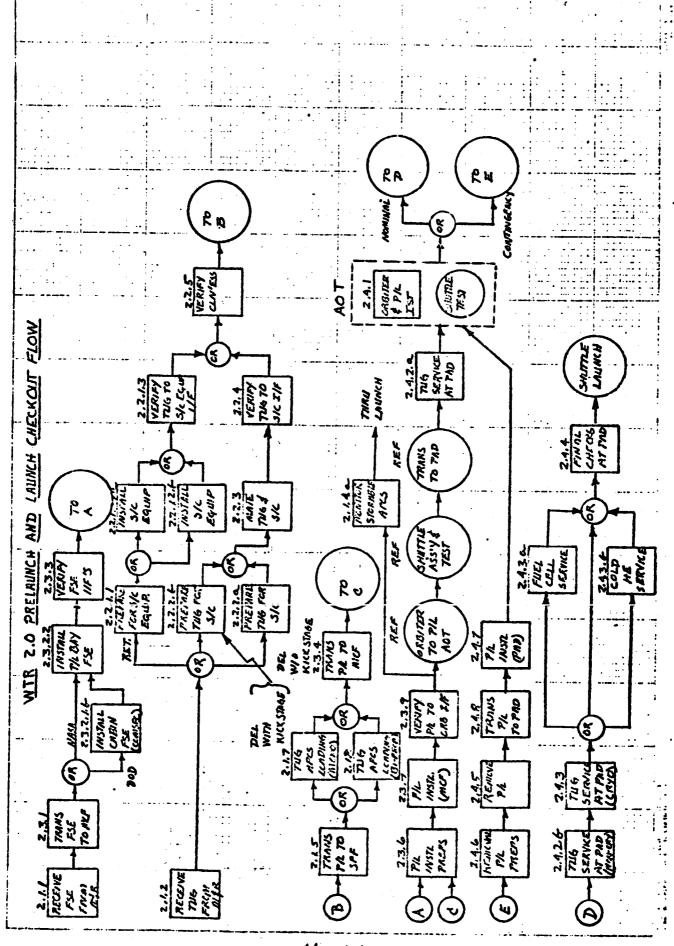


FIG. 1.3.3 -6 (CONT.)

FIG 11.3.3-7

FIG. 11.3 5-7 (CONT.)

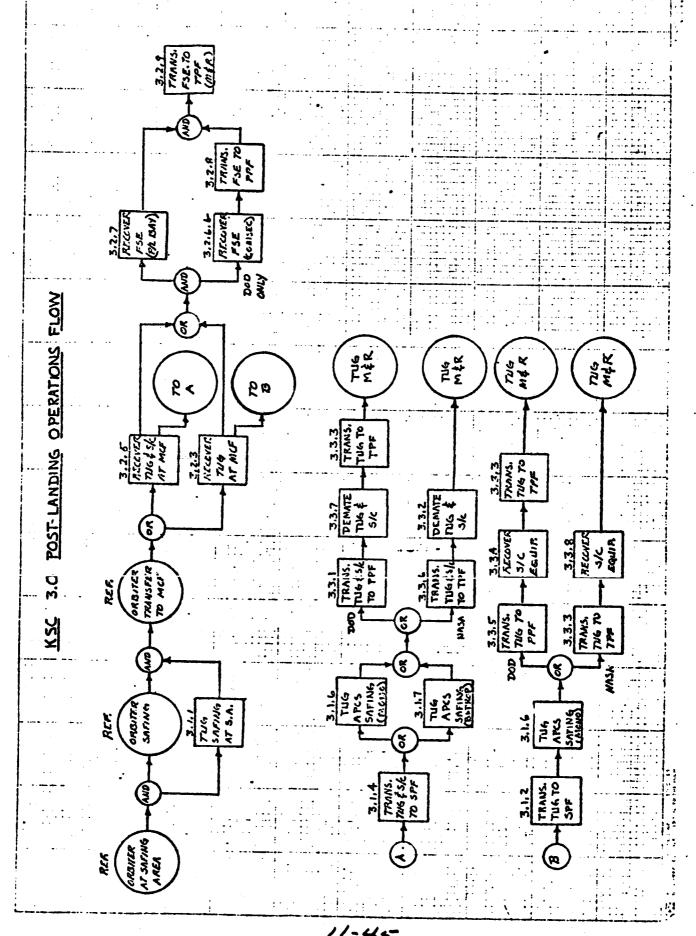
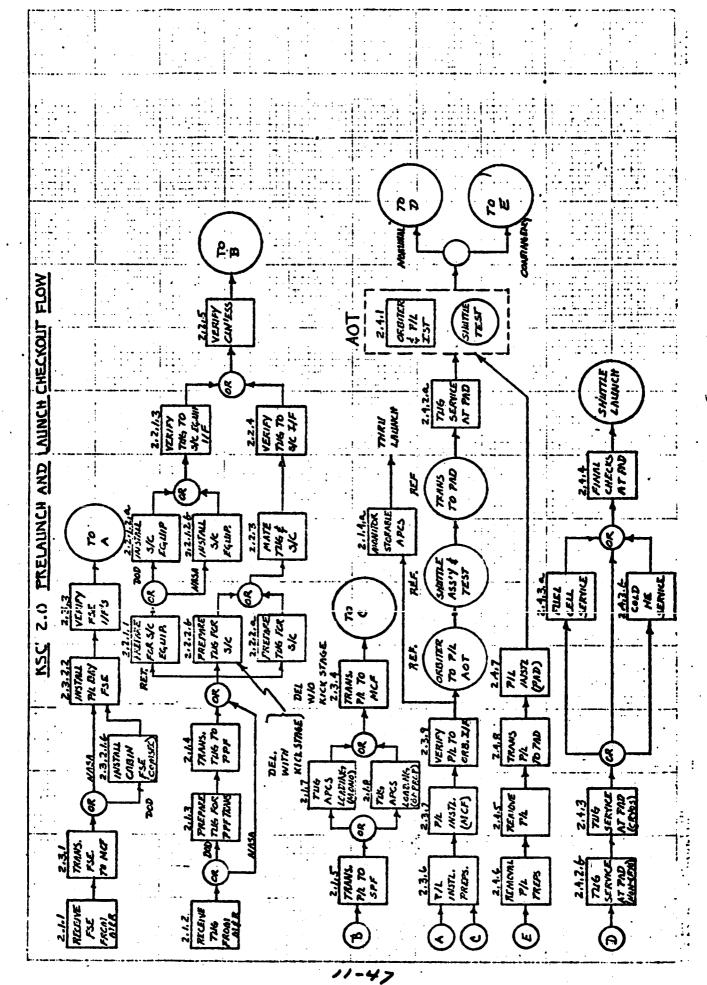


FIG. 11.3.3-8



11.3.3-8 (CONT.)

- 11.3.4 Tug Operations Sensitivities to Tug Configurations
- Each To option configuration was assessed with respect to
  - A. Turnaround time
  - B. Manpower
  - C. GSE
  - D. Depot maintenance
  - E. Facilities

for the following Tug configuration differences

- A. Retrieval vs. no-retrieval
- B. Mono-propellant vs bi-propellant
- C. Cold helium vs ambient helium pressurization
- D. Fuel cells vs batteries
- E. NASA security vs DOD security
- F. Kick stage vs no kick stage
- G. Engine configuration
- H. On-orbit time
- I. Autonomy level
- J. Abort requirements

Results of these sensitivity analyses are summarized as follows:

# Turnaround Time

The key drivers in Tug ground turnaround time sensitivity to Tug configurations are:

- A. Retrieval vs no retrieval
- B. Monopropellant vs bi-propellant
- C. Kick stage vs no kick stage

Retrieval, bipropellant, and kick stage ground operations increase ground turnaround by 5 hours, 15 hours, and 1 hour respectively.

The configurations which influence manpower are as follows: Manpower

- Cold helium pressurization operations increase the mandatory required manpower by four people
- Fuel cell operations increase mandatory required manpower by six В. people.

- C. DOD security requirements increase the maximum required manpower by two people.
- D. Kick stage operations increase the maximum required mangower by six people.

#### GSE

The key drivers in GSE sensitivity to Tug configurations are as follows:

- A. Retrieval operations requires spacecraft/Tug demating GSE at the PPF and TPF.
- B. Bi-propellants require bi-propellant handling and storage GSE at the storable propellant facility.
- C. Cold helium operations adds maintenance and refurbishment GSE at the MCF and servicing GSE at the launch pad.
- D. Fuel cell operations add maintenance and refurbishment GSE at the MCF and servicing GSE at the launch pad.
- E. DOD security requires COMSEC checkout GSE at the PPF and an interfacility security transport vehicle for Tugs which fly classified payloads.
- F. Kick stage operations add additional kick stage/Tug integration GSE at-the PPF or TPF.

## Depot Maintenance

The configurations which influence depot maintenance are:

- A. Monopropellant APCS requires the replacement of 12 sets of aft firing thrusters.
- B. Category 2A RL-10 engine requires 12 engine overhauls.

  Category I RL-10 engine requires 18 engine overhauls.

#### **Facilities**

Facilities are relatively insensitive to Tug configurations with exception to kick stage missions which require an ordnance facility for kick stage storage and assembly.

Option Sensitivity	Option 1	Option 2	Option 3I	Option 3F	Option 3
Tue Configuration	Turna round Time	Tu:naround Time	Turnaround Time	Turnaround Time	Turnaround
Retrieval/No Retrieval	Retrieve capabil- ity increases turnaround 5 hrs	No retrieval capability reduces	Same as Option 2	Same as Option 2	Same as Option 2
Monopropellant/ Bi-propellant	Bi-propellant in- creases turn- around 15 hours	Monopropellant decreuses turn- around 15 hrs	Bi-propellant in- creases turn- eround 15 hrs	Monopropellant decreases turn- around 15 hrs	Monopropellant reduces 15 hrs Bipropellant in- creases 15 hrs.
Cold Helium/ Ambient Helium Pressurization	Cold helium has no effect	Cold helium has no effect	Cold helium has no effect	Ambient helium has no effect	No effect
Fuel Cells/ Batteries	Fuel cells have no effect	Batteries have no effect	Fuel cells have no effect	Batteries have no effect	No effect
NASA/DOD Security	DOD security adds 7 hrs to turn-around	Same as Option 1	Same as option 1	Same as Option 1	Same as Option 1
Kick Stage/No Kick Stage	Kick stage adds 1 hr to turn- around	Same as Option 1	Same as Option 1	Same as Option 1	Same as Option 1
Engine Configuration	Cat 2A RL-10 has no effect	Cat 1 RL-10 has no effect	Cat 2A RL-10 has no effect	Cat 2A RL-10 has no effect	Cat 2A RL-10 has no effect
On-Orbit Time	No effect on ground ops	Same as Option 1	Same as Option 1	Same as Option 1	Same as Option 1
Autonomy Level	Autonomy Level III has no effect	Autoncmy Level IV	Same as Option 1	Same as Option 2	No effect
Abort Req'mts	No effect	No effect	No effect	No effect	No effect

Option Sensitivity	Option 1	Option 2	Option 3I	Option 3F	Option 3
Tug Configuration	Manpower	Мапрочег	Manpower	Manpower	Manpower
Retrieval/No Retrieval	Retrieval has no effect on man- power requmts	No retrieval has no effect on man- power requmts	Same as Option 2	Same as Ortion 2	No effect
Monopropellant/ Bi-propellant	Bi-propellant has no effect on maximum manpower req'd	Monopropellant has no effect on maximjm manpower req'd	Same as Option 1	Same as Option 2	No effect
Cold Helium/ Ambient Helium Pressurization	Cold Helium in- creases mandatory manpower by 4	Same as Option 1	Same as Option 1	Ambient helium reduces mandatory manpower by 4	Ambient helium reduces mandatory manpower by 4
Fuel Cells/ Batteries	Fuel cells in- crease mandatory manpower by 6	Batteries reduce mandatory man- power by 6	Same as Option 1	Same as Option 2	Fuel cells increase mandatory req'mt by 6. Batteries reduce mandatory req'mt
NASA/DOL Security	DOD security in- creases max. man- power req'mt by 2	Same es Option 1	Same as Option 1	Same as Option 1	DOD security in- creases max. man- power regimt by 2
Kick Stage/ No Kick Stage	Kick Stage in- creases max. man- power reqm't by 6	Same as Option 1	Same as Option 1	Same as Option 1	Kick Stage in- creases max. man- power req'mt by 6
Engine Configuration	cat 2A RL-10 has no effect	Cat 1 RL-10 has no effect	Same as Option 1	Same as Option 1	No effect
On-Orbit Time	6 day on-orbit time has no effect	36 hour on-orbit time has no effect	6 day on-orbit	36 hour on-orbit time has no effect	No effect
Autonomy Level	Autonomy Level III has no effect	Autonomy Level IV has no effect	Same as Option 1	Same as Option 2	No effect
abort Rec'mts	No effect on man- power requits	Same as Option 1	( e as Option 1	Same as Option 1	No effect on man-

					)
Optign	Option 1	Option 2	Option 3I	Option 3F	Option 3
Tug Configuration	SSE	3SE	SSE	GSE	389 189
Retrieval/No Retrieval	Retrieval requires S/C demate GSE at PPF and TPF	No retrieval elim- inates S/C demate GSE at PPF and TPF	Same as Option 2	Same as Option 2	No retrieval elim- inates S/C demate GSE at PPF and IPF
Monopropellant/ Bi-propellant	Bi-propellant requires B-prop handling and storage GSE at SPF	Monopropellant eliminates bi-prop handling and stor- age GSE at SPF	Same as Option 1	Same as Option 2	Same as Options 3I and 3F
Cold Helium/ Ambient Helium Pressurization	Cold hellum adds M&R and servicing GSE at TFF and launch pad	Rame as Option 1	game as Option 1	Ambient helium eliminates M&R and servicing GSE for cold helium at TPF and launch pad	Same as Options 31 and 37
Fuel Cells/ Batteries	Fuel cells and M&R and servicing GSE at TPF and launch pad	Batteries elimi- nate fuel cell M&R and servicing GSE at TPF and launch pad	Same as Option 1	Same as Option 2	Same as Options 31 and 3F
MASA/DOL Security	DOD security requires COMSEC checkout GSE and inter-facility security transport vehicle	Same as Option 1	Same as Option 1	Same as Option 1	Same as Option 1
Kick Stage/ No Kick Stage	Kick Stage requires additional Tug/Kick-stage integration GSE	Same as Option 1	Same as Option 1	Same as Option 1	Same as Option 1
Engine Configuration	Cat 2A RL-10 has no effect	Cat 1 RL-10 has no effect	Same as Option 1	Same as Option 1	Same as Option 1

100		6 20 1	10 10 10	00 mm	
Sensitivity	1 0000	2 10000	operon 31	Je notado	Çetlon 3
Configuration	GSE	GSE	SSE	GSE	E95
On-Orbit Time	No effect	No effect	No effect	No effect	No effect
Autonom, Level	Level III has no effect	Level IV has no effect	Same as Option 1	Same as Option 1	No effect
Abort Req'mts	No effect	No effect	No effect	No effect	No effect

Option	Option 1	Option 2	Option 3I	Option 3F	Option 3
Tug Configuration	Depot Maintenance	Depot Maintenance	Depot Maintenance	Depot Maintenance	Depot Maintenance
Retrieval/ No Retrieval	Retrieval has no effect	No retrieval has no effect	Same as Option 2	Same as Option 2	No effect
Monopropellant/ Bi-propellant	Bi-propellant re- quires no depot maintenance	Monopropellaht re- quires replacement of 12 aft firing thruster sets	Bi-propellant re- quires no depot maintenance	Bi-propellant re- quires replacement of 12 aft firing thruster sets	Same as Option 3I and 3F
Cold Heilum/ Ambient Hellum Pressurization	Cold hellum requires no depot	Same as Option 1	Same as Option 1	Ambient helium re- quires no depot maintenance	Same as Options 31 and 3F
Fuel Cells/ Batteries	Fuel cells require no depot maint.	Fuel sells req'd for 6 day mission	Fuel cells require no depot maint.	Fuel cells req'd for 6 day mission	Same as Options 3I and 3F
NASA/DOD Security	No effect	No effect	No effect	No effect	No effect
Kick Stage/ No Kick Stage	No effect	No effect	No effect	No effect	No effect
Engine Configuration	Cat 2A RL-10 Requires 12 engine overhauls	Cat 1 RL-10 requires 18 engine overhauls	Same as Option 1	Same as Option 1	Same as Option 1
On-Orbit Time	No effect	No effect	No effect	No effect	No effect
Autonomy Level	No effect	No effect	No effect	No effect	No effect
Abort Reg'mts	No effect	No effect	No effect	No effect	No effect
·	A Crest	ang ga sa minar - a		mater of materials where	

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Option Sensitivity	Option 1	Option 2	Option 3I	Option 3F	Option 3
Tug Configuration	Facilities	Facilities	Facilities	Facilities	Facilities
Retrieval/ No Retrieval	Retrieval has no effect	No Retrieval has no effect	Same as Option 2	Same as Option 2	No effect
Monopropellant/ Bi-Propellant	Bi-propellant has no effect	Monopropellant	Same as Option 1	Same as Option 2	No effect
Cold Helium/ Ambient Helium Pressurization	Cold helium has no effect	Same as Option 1	Same as Option 1	Ambient helium has no effect	No effect
Fuel Cells/ Batteries	Fuel cells have no effect	Batteries have no effect	Same as Option 1	Same as Option 2	No effect
NASA/DOD Security	DOD security requires a PPF	DOD security requires a PPF	DOD security requires a PPF	DOD security requires a PPF	DOD security requires a PPF
Kick Stage/ No Kick Stage	Kick stage requires ordnance facility	Same as Option 1	Same as Option 1	Same as Option 1	Kick stage requires ordnance facility
Engine Configuration	Cat 2A RL-10 has no effect	Cat 1 RL-10 has no effect	Same as Option 1	Same as Option 1	No effect
On-Orbit Time	No effect	No effect	No effect	No effect	No effect
Autonomy Level	No effect	No effect	No effect	No effect	No effect
Abort Req'mts	No effect	No effect	No effect	No effect	No effect
nga ga sa permaki na anga	agiri kanada yang amang ang ang ang ang ang ang ang ang ang				

## 11.3.5 Operations Constrained by the Orbiter

The Tug operations which are constrained by the Orbiter for Option 3I and 3F are listed below according to their corresponding Function Breakdown Number. These operations are time constrained in order to not interfere with the Orbiter ground turnaround schedule.

# F.B.N TUG OPERATIONS CONSTRAINED BY THE ORBITER

### 2.3 TUG/SHUTTLE MATE

- 2.3.7 Payload Installation MCF
- 2.3.9 Verify Payload-To-Shuttle Interfaces

#### 2.4 COUNTDOWN

- 2.4.1 Orbiter/Payload Integrated System Test
- 2.4.la Monitor Storable ACPS
- 2.4.2a Tug Service at Pad
- 2.4.2b Tug Service at Pad (Non-Cryo)
- 2.4.3 Tug Service at Pad (Cryo's)
- 2.4.4 Final Checks at Pad
- 2.4.5 Remove Payload (Pad)
- 2.4.6 Payload Installation or Removal Preps (Pad)
- 2.4.7 Payload Installation (Pad)

#### 3.1 SAFE AND SECURE

- 3.1.1 Tug Ground Safing at Safing Area
- 3.1.1a Tug Ground Safing at Safing Area

### 3.2 SHUTTLE/TUG DEMATE

- 3.2.3 Recover Tug at MCF
- 3.2.5 Recover Tug and S/C at MCF
- 3.2.6b Recover FSE (Cabin) Equipment (COMSEC)
- 3.2.7 Recover FSE (Payload Bay) Equipment

11.3.6 Ground Turnaround Operations Descriptions and Timelines
The operational timelines for ETR and WTR as summarized in section 11.3.3 were
developed using the methodology described in section 11.3.1 and are presented in the pages following section 11.3.7.

As an example of how the decisions were made for where certain functions are performed, trade study sheets on Tug/Shuttle Demote and On Pad vs Off Pad Installation are inserted after the timelines. These sheets also provide the response to action items 98 and 139.

### 11.3.7 Task Description Sheets

The detailed timelines of section 11.3.6 consist of several hundred separate tasks. Each of these tasks, in turn, is described by a separate Task Description Sheet. Because of the volume of these sheets, they are not presented here but rather are included in appendix 11.10-D. Also included in appendix D is the baseline time line (which includes all operations for all options) from which the specific option time line was developed.

### TASK TIMELINES

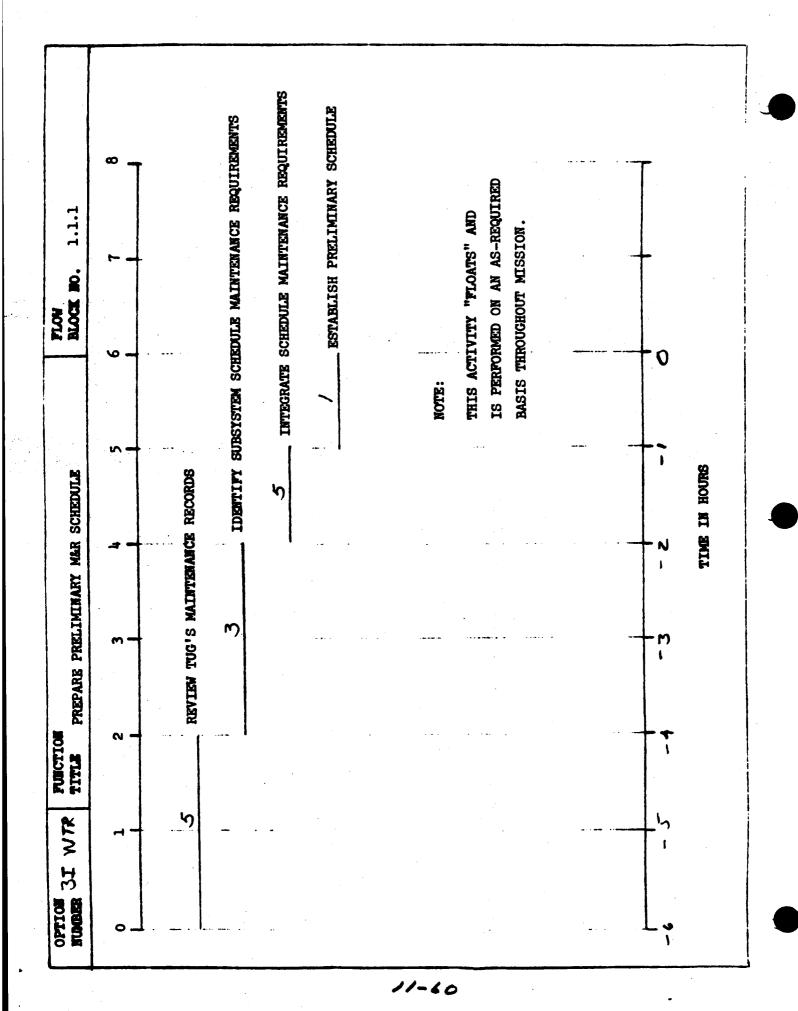
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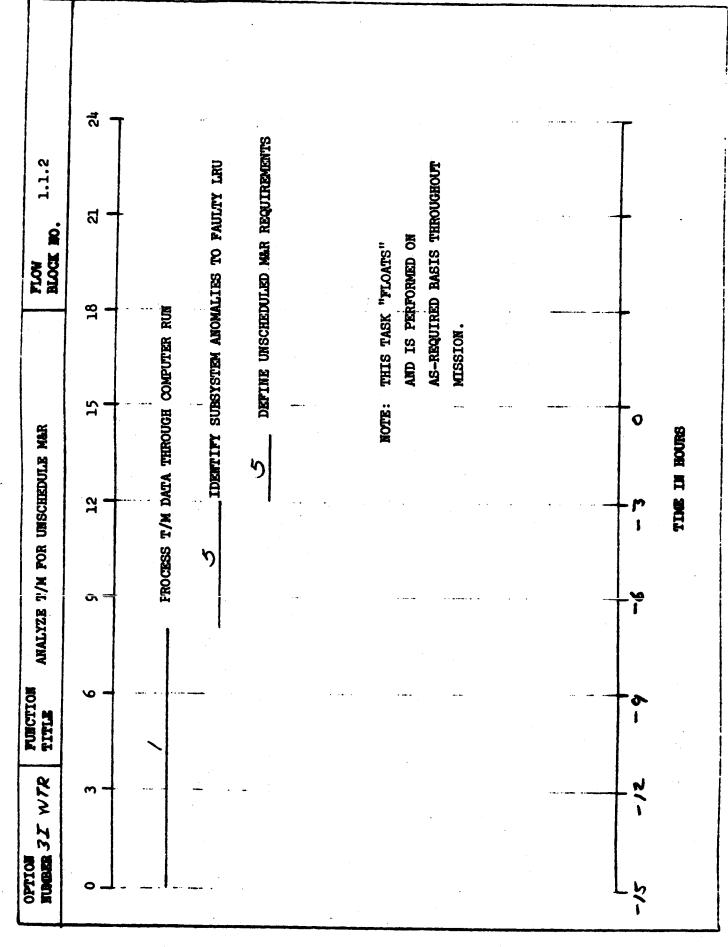
THE CRYOGENIC TUG

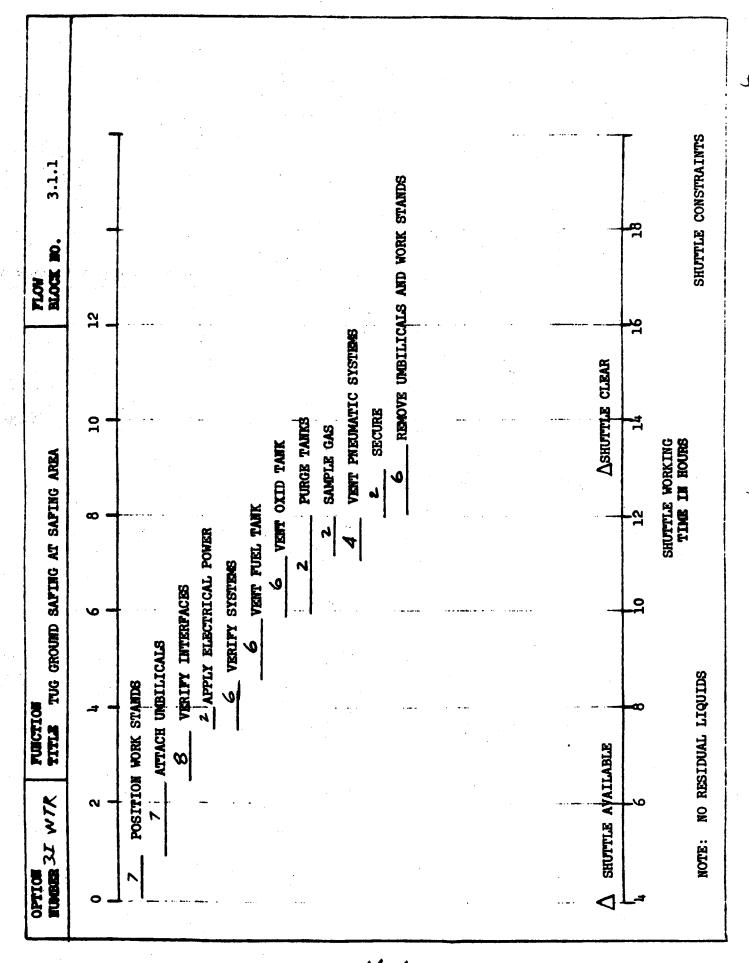
GROUND AND LAUNCH OPERATIONS

OPTION NO. 31 WTR

SEPTEMBER 1973







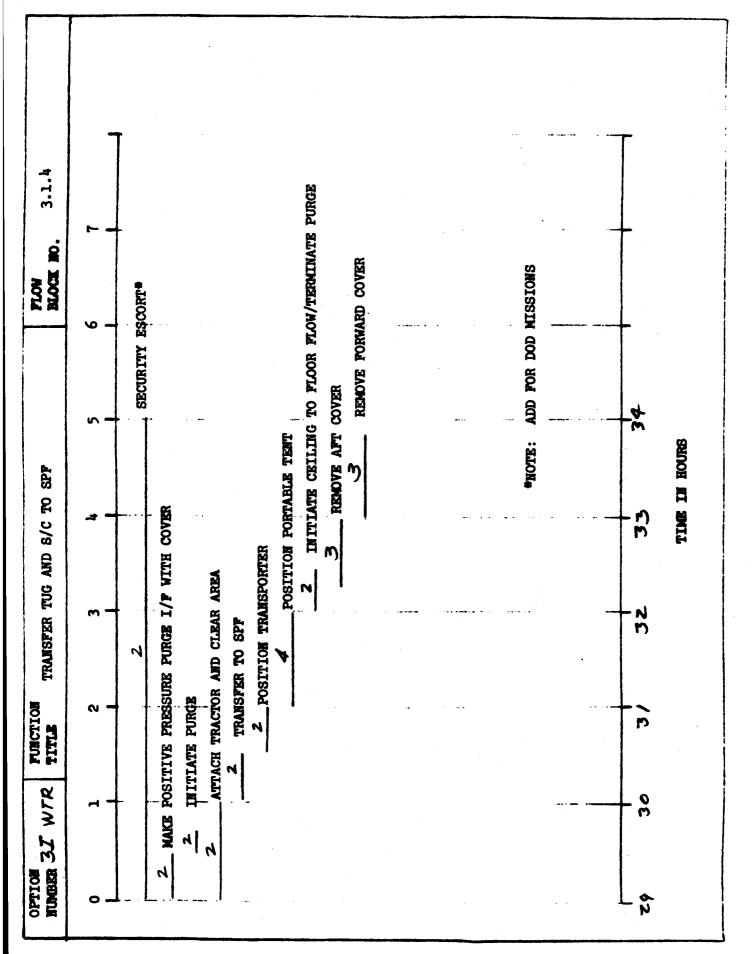
FLOW 3.2.5	9		·					TER			RTER	PREPARE PAYLOAD (COVER LENS AND PROTUB.)	UNPACK COVERS	POSITION CRAME	LIFT CENTER COVER AND DRAPE	LIP FO	LIFT AFT CO	LACE COVERS	SEAL SEANS	ARBIOVE TENT		27 28 29		SHUTTLE CONSTRAINT
TIG AND S/C AT MCP	S = -	D REMOVAL (ORBITER)		R AND S/C/ORBITER INTERFACES			IOWIS PREPARE TRAISPORTER	LIFT AND PLACE ON TRANSPORTER	4 DISCONNECT SLINGS	2 DETACH TAG LINES	3 SECURE ON TRANSPORTER	ı	2 UNPACK	OITION /						-	ORBITER CLEAR	24 25 26	SHUTTLE WORKING TIME IN HOURS	
WTR TITLE RECOVER THE	1 2	PREPARATION COMPLETE FOR PAYLOAD	POSITION TRANSPORTER	DISCORNECT TUG/ORBITER	4 ATTACH BLINGS	2 ATTACH TAG LINES	7 FREE TIEDO	2				• • • • • • • • • • • • • • • • • • •						· .			-	22 23		
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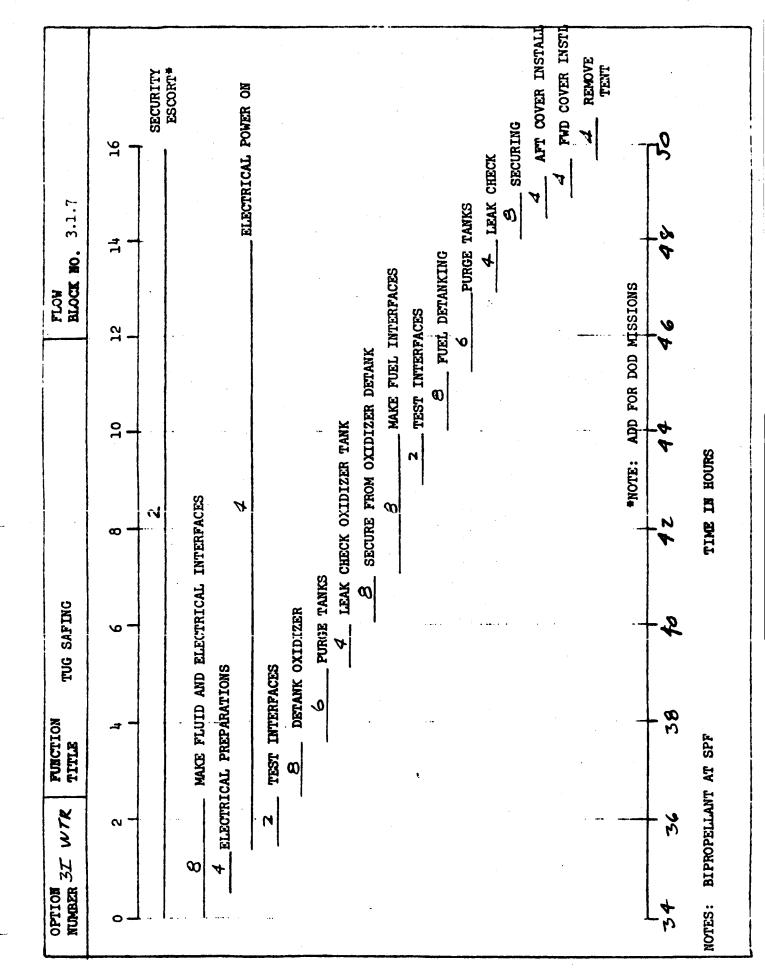
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PLON 3.2.7 MLOCK NO. 3.2.7	6 7					ORT HARDWARE	RECEIVE AND STOW FSE IN TRANSPORT		REMOVE WORKSTANDS					30	
(PAYLOAD BAY) EQUIPMENT	5		GSE AND FLIGHT UMBILICALS	EL (T-26)	REMOVE LOX DUMP INTERPACE REMOVE RMS END EFFECTORS	* REMOVE TUG SUPPORT HARDWARE	RECEIVE AND STON	SECURE PSE	4	••• •	• ••.	·	<del></del>	74	TIME IN HOURS
RECOVER FSE (PAYLOAD BA	м-	IDS AND PLATFORMS	REMOVE GSE AND FLI	SERVI	Z REMOVE R		4						-	\$2 62	7116
TITLE	<b>≈</b> −	POSITION WORKSTANDS AND	 9							 			••	92	
OPTION 3. WTR	0~	*								• •		- · -		24 25	

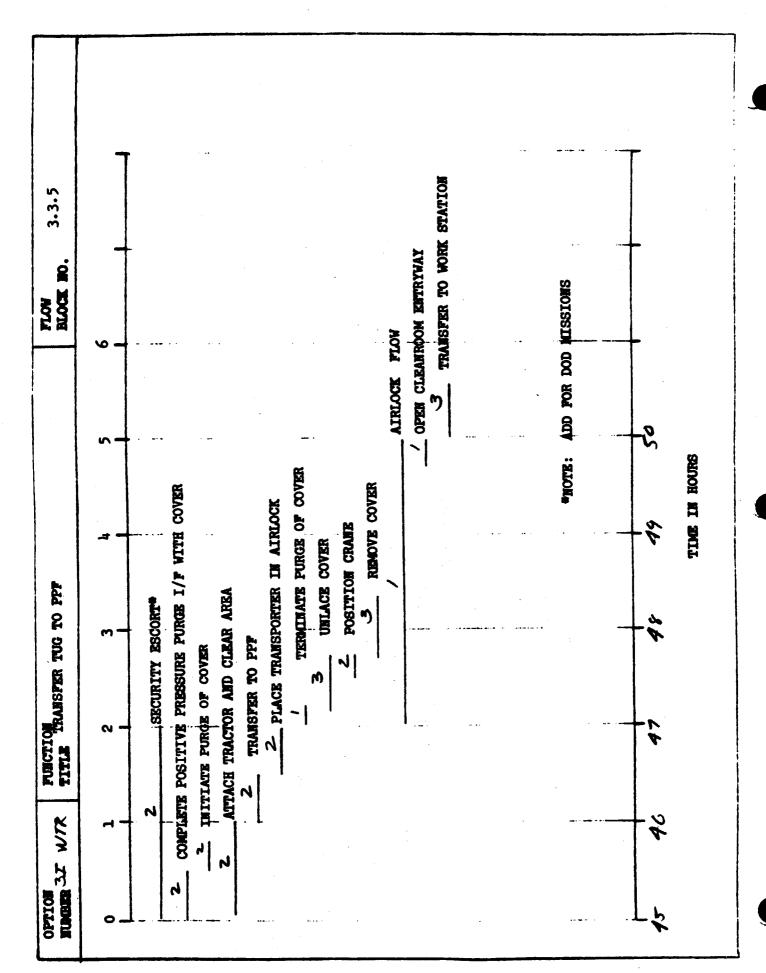
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3.2.8	-															<b></b>		. <b></b>	حنو د		
FLOW BLOCK NO.	<b>9</b> -		••					SE WORK AREA		AIRLOCK	AIRLOCK FLOW					ADD FOR DOD MISSIOMS		·		<b>+</b>	
	<b>~</b>		·•	<del>.</del>				TRANSPORT TRANSFER TO PSE WORK AREA	UNITOAD DOD PSE	TRANSPORT TO AIRLOCK						MOTE: ADD FOR DO		<del>-</del>	- ·- <del></del>	37	OURS
E TO PPF	<b>4</b> =		·	·-·	IN AIRLOCK	AIRLOCK FLOW	OPEN ENTRYWAY	1	- 1	4				•		)## 		• ·		N A	TIME IN HOURS
TRANSFIER FSE	e –	SECURITY ESCORT		ISPER TO PPF	POSITION TRANSPORT IN AIRLOCK	AIR AIR	3do 7-	4				. ,	•.• .		• •		-			35	
PURCTION TITLE	~ <b>-</b>	2 (SEC	TRAISFER CLEAR AREA	TRANSPORT TRANSFER TO PPF	2 POSITE													7).		34	
OPTION MINGER 3.2. WTR	1		2 TRANSFE	2	. 1	•. •												1. 1. <del></del>	:	33	
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1.1.3	60° -		REDUCT.	-
FLOW NO. 1	9-	AND INCOMENIATION OF TAXABLE		10
	<b>6</b>	THINDUDAME GARDONIC EN		36 39 Tide in hours
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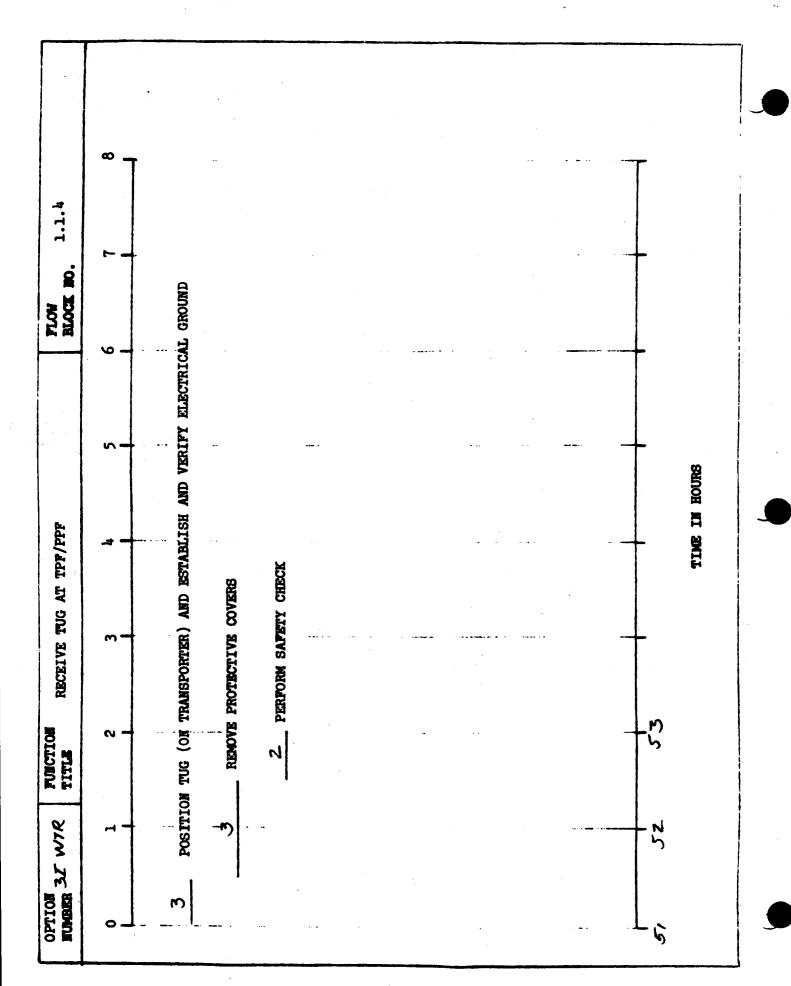
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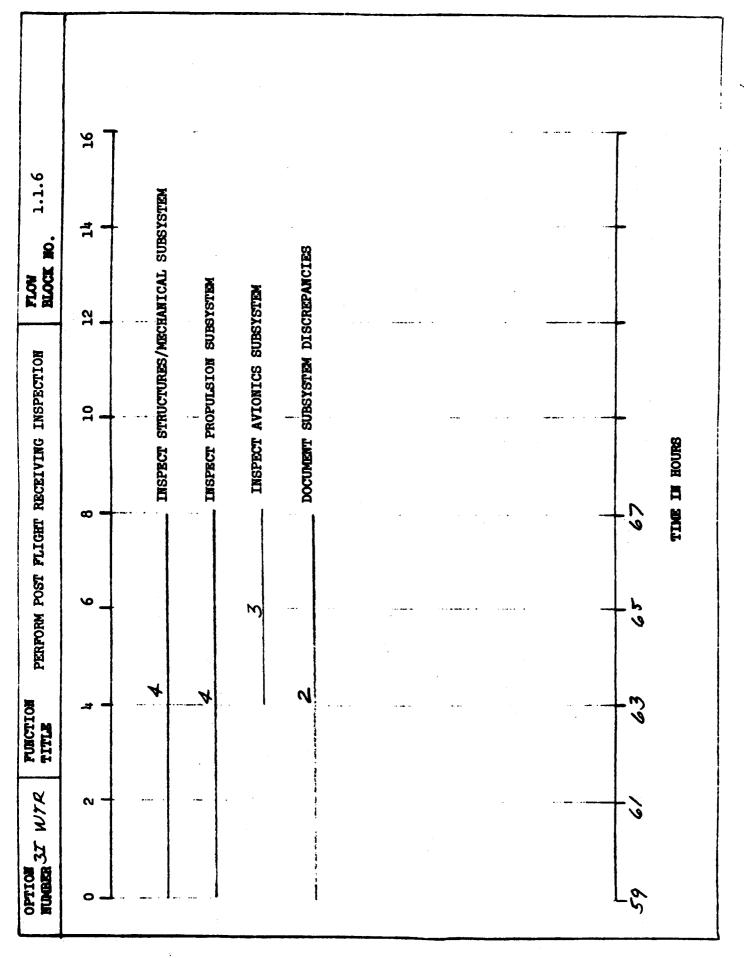


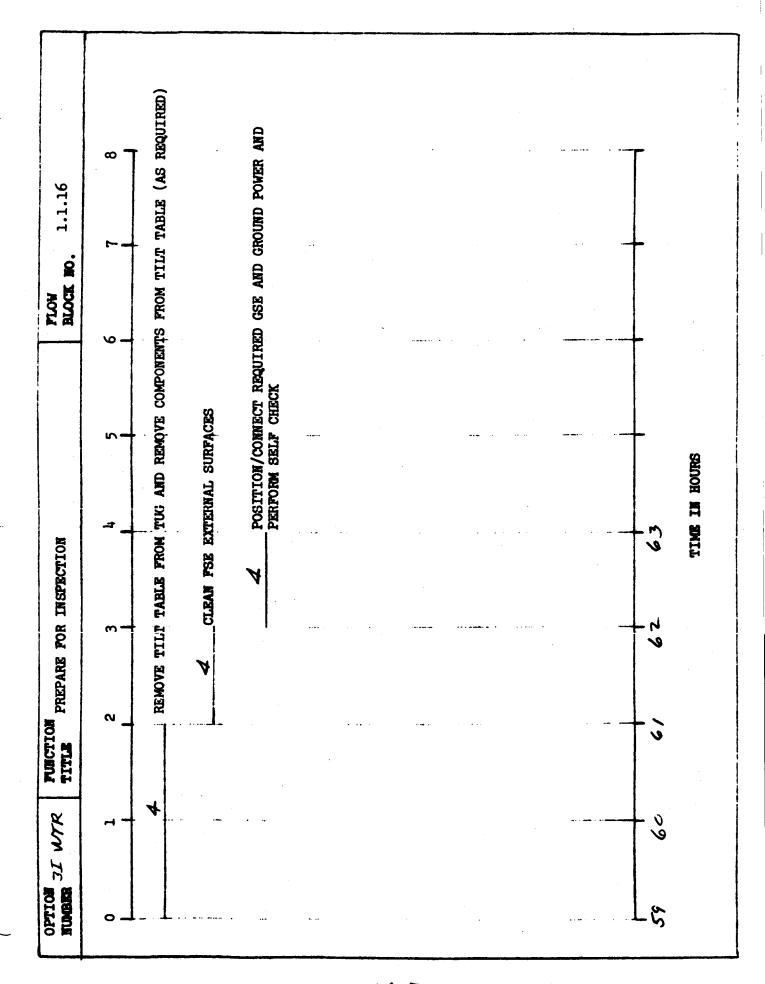


3.3.7	€ .												TO COVER				-				
FLOW BLOCK NO.	9		<u>.</u> .				PAGNT		TRANSFER TUG TO AIRLOCK	OPEN CLEANROOM ENTRYWAY	AIRLO CK FLOW	POSITION CRANE	THE TAKEN THE COVER					+	۲,		
ACECRAFT			•			CECRAFT	REMOVE SPACECRAPT EQUIPMENT	REMOVE WORK STANDS	TRANSFER T	OPEN CLEAN	_	2 POSITIC				<b></b>	· · · · · · · ·		57 SB	TIME IN HOURS	
DEMATE TUG AND SPACECRAFT	es =	STAND	CRAFT SLIIG(S)	,	DEMATE SPACECRAFT AND TUG	THANSFER SPACECRAFT	7	4	••				<del></del>	 <b></b> .			-		9		
Z WTR TITLE	1 2	- POSITION END WORK STAND	ATTACH SPACECRAFT SLING(8)	- POSITION CRAME	4													+;	50 - 40		
OPTION ST. WTR.	٥_	*)			•	···											-		53		

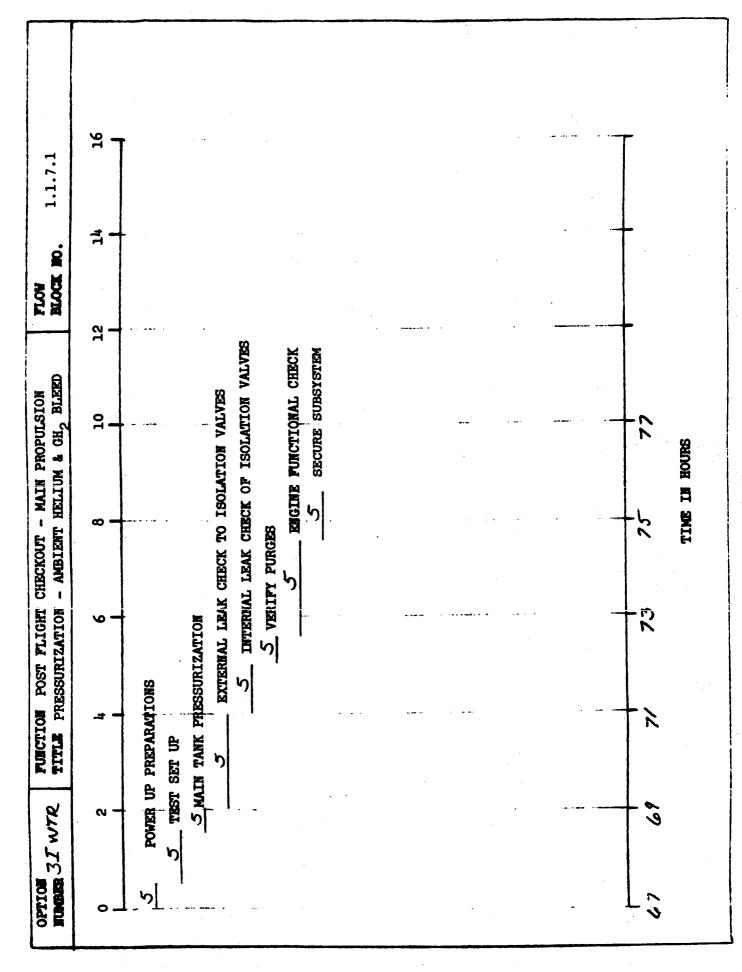


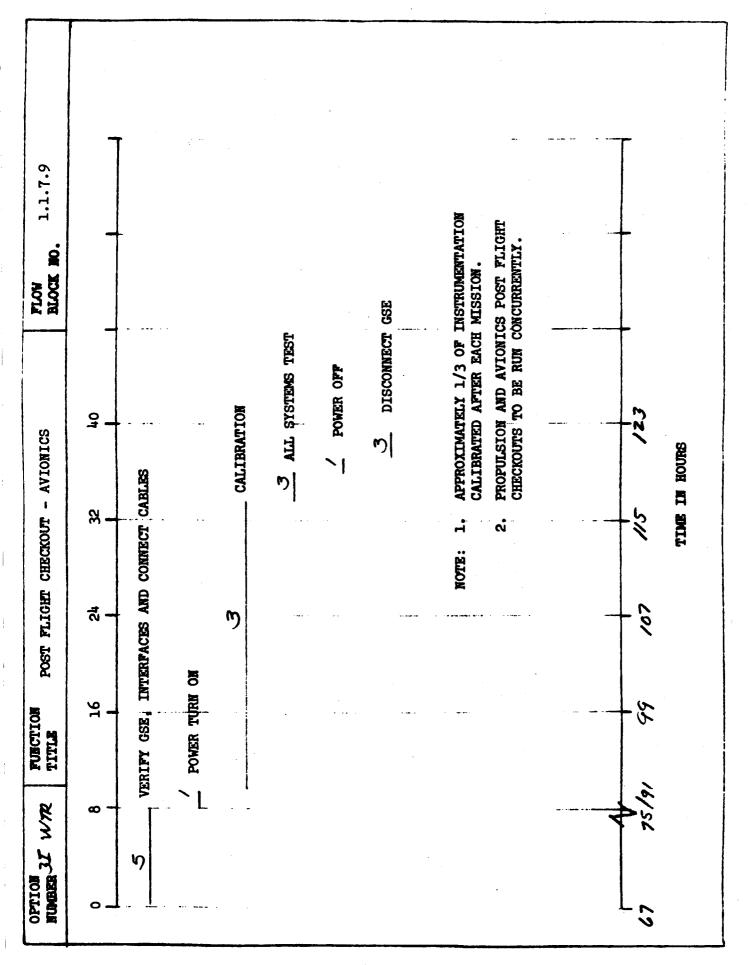
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1.1.5	8 7					IND POWER AND			•			
FLOW BLOCK NO.	9			CONFINED AREAS	IRRIER	RED GSE AND GROU						
AND C/O	2	, <u>.</u>	-	INSTALL AIR CONDITIONING (BREATHABLE AIR) IN CONFINED AREAS	REMOVE FORWARD SKIRT METEOROID BARRIER	PUSITION/CONNECT REQUIRED GSE AND GROUND POWER AND PERFORM SELF CHECK		<b></b>			85	IN HOURS
FOR INSPECTION AND C/O		<b></b> .	/DOORS	ONDITIONING (	EMOVE FORWARD						15	TIME IN
PREPARE F	m <del>-</del>	m	OPEN ACCESS PANELS/DOORS	INSTALL AIR C	4	4	· • · · ·				12	
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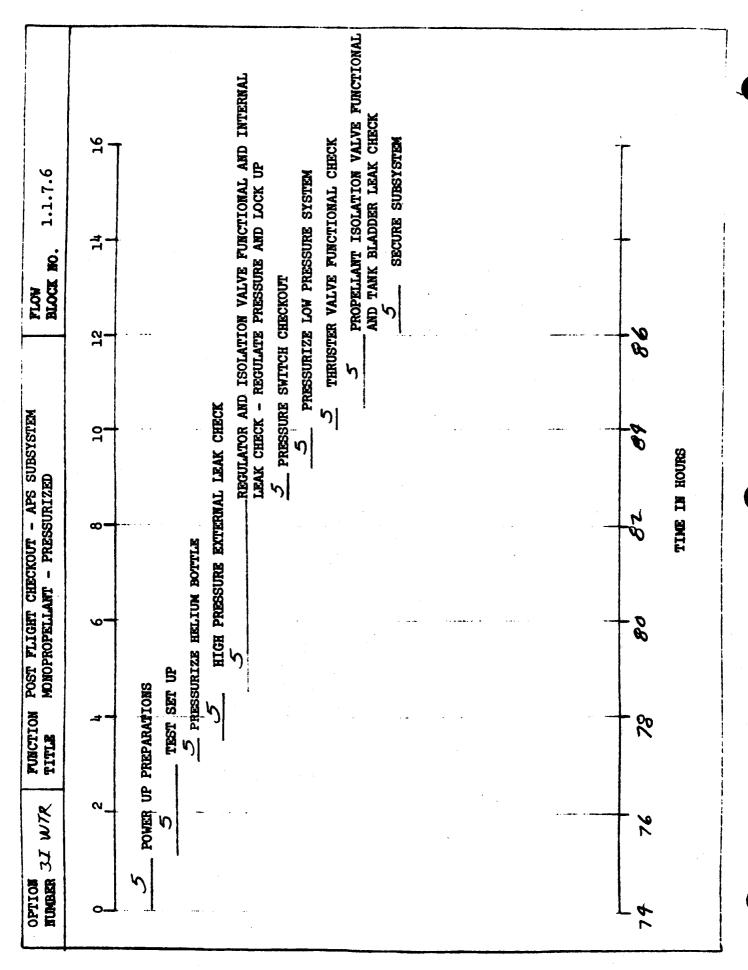


3 INSPECT TILT TABLE  2 INSPECT CAUTION AND WARNING INTERPACE EQUIPMENT  2 INSPECT RAW SUPPORT EQUIPMENT  4 INSPECT PLAID UNBILLICALS  3 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  2 INSPECT PLAID UNBILLICALS  4 INSPECT PLAID UNBILLICALS  5 INSPECT PLAID UNBILL UNBILL  5 INSPECT PLAID UNBILL UNBILL  5 INSPECT PLAID UNBILL UNBILL  5 INSPECT PLAID UNBILL  5 INSPECT PLAID UNBILL UNBILL  5 INS									
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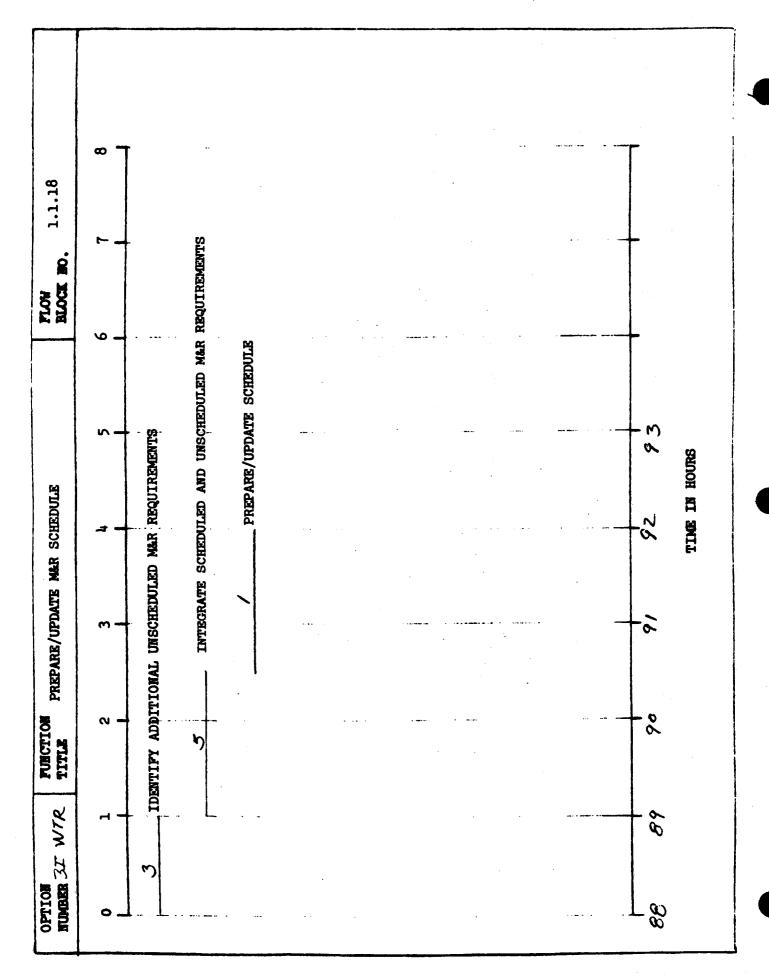




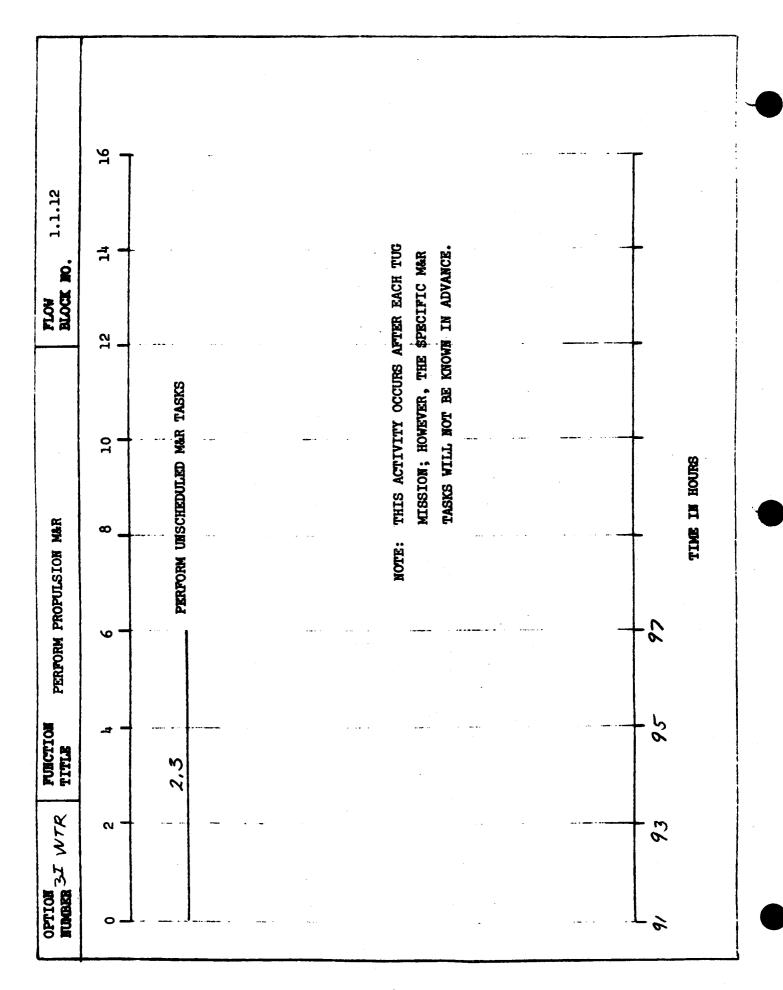
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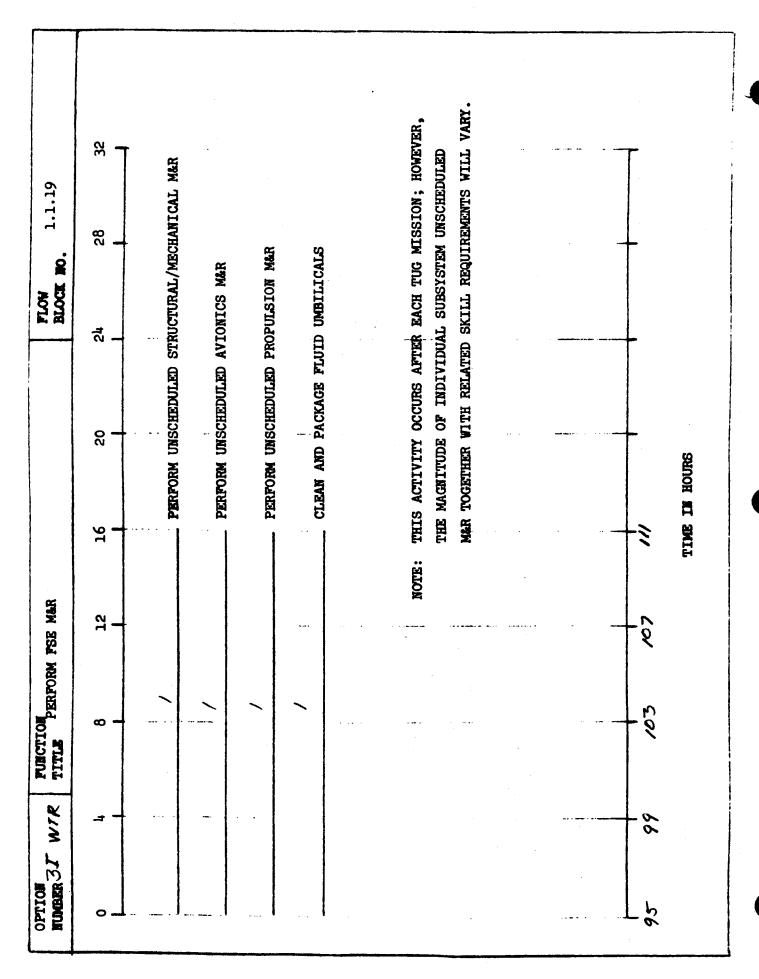
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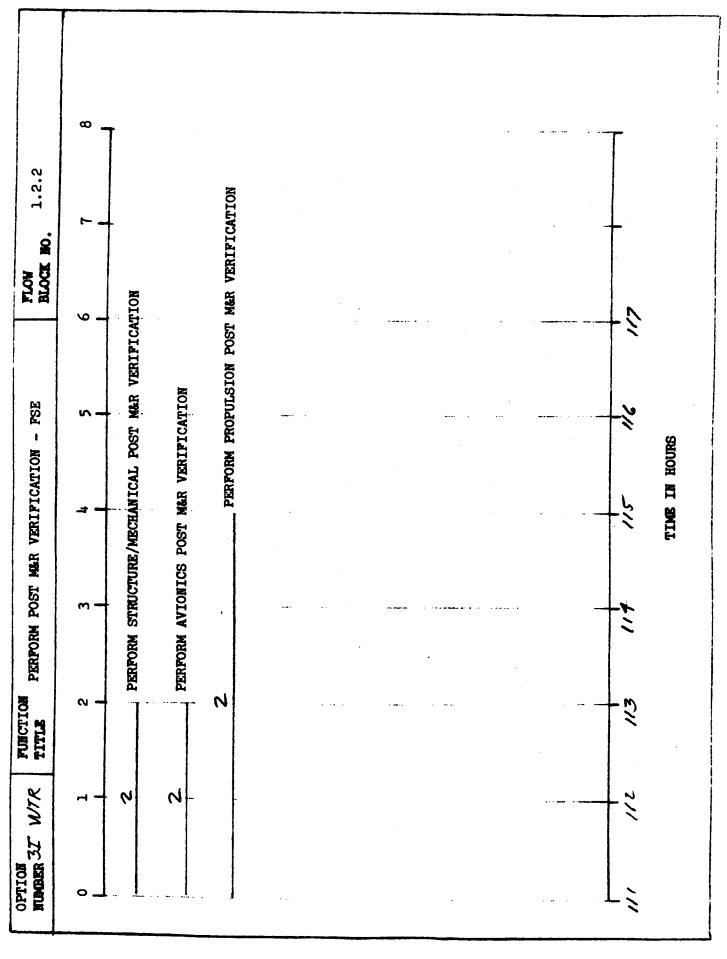
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PERFORM STRUCTURAL/MECHANICAL MAR	<b>м</b> —	PERFORM UNSCHEDU				NOTE: 1	2. E	 			
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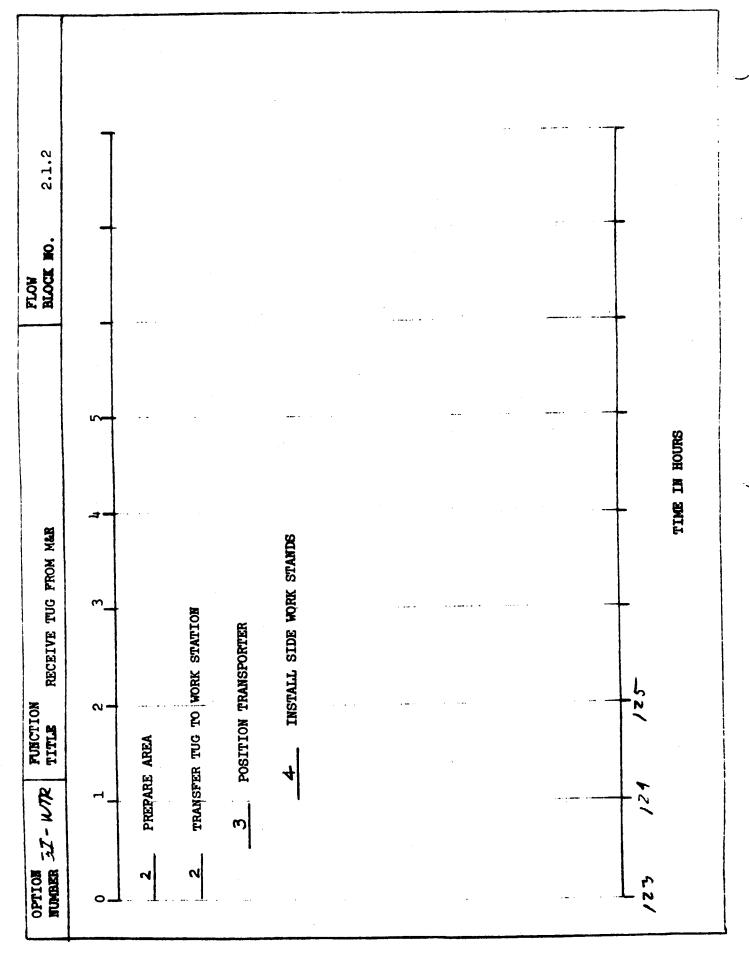
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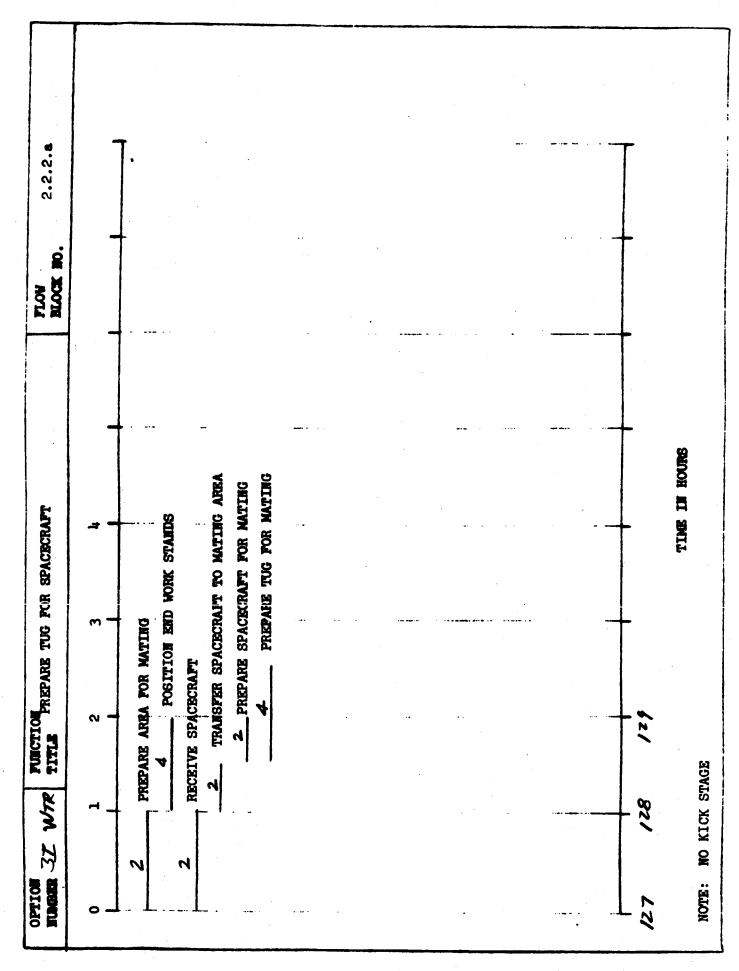


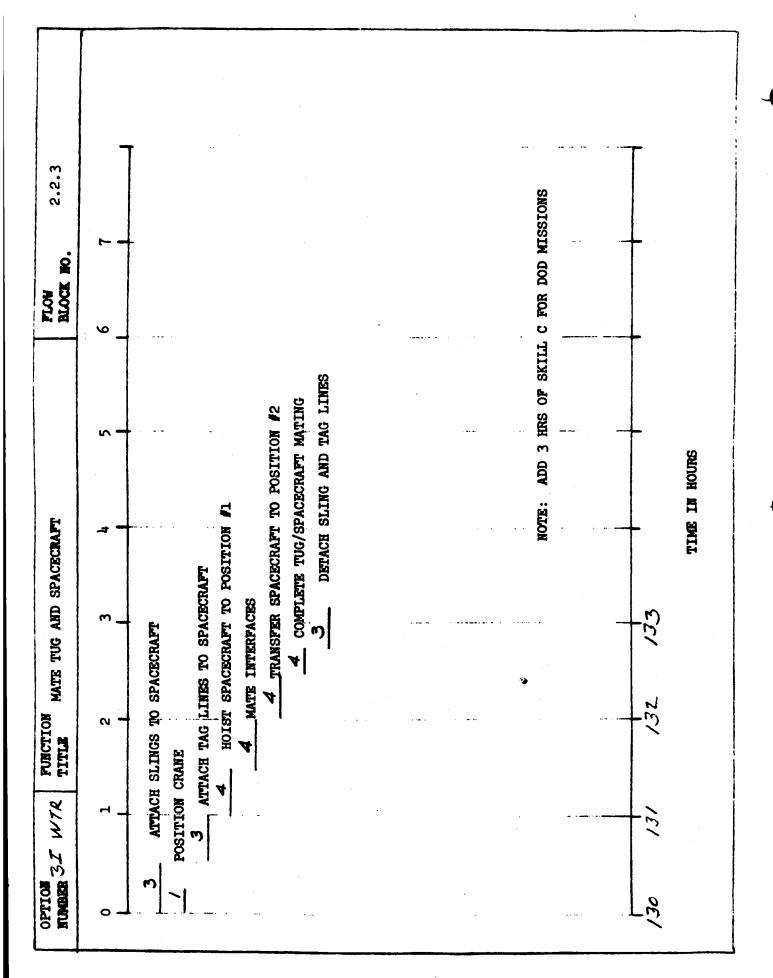
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	5				<b></b>				IOURS
IGER GSE	<u></u>				· .	•			TIME IN HOURS
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72 FUNCTION	1 2 1	DISCOMMECT GSE	- MOVE GSE AN					22	
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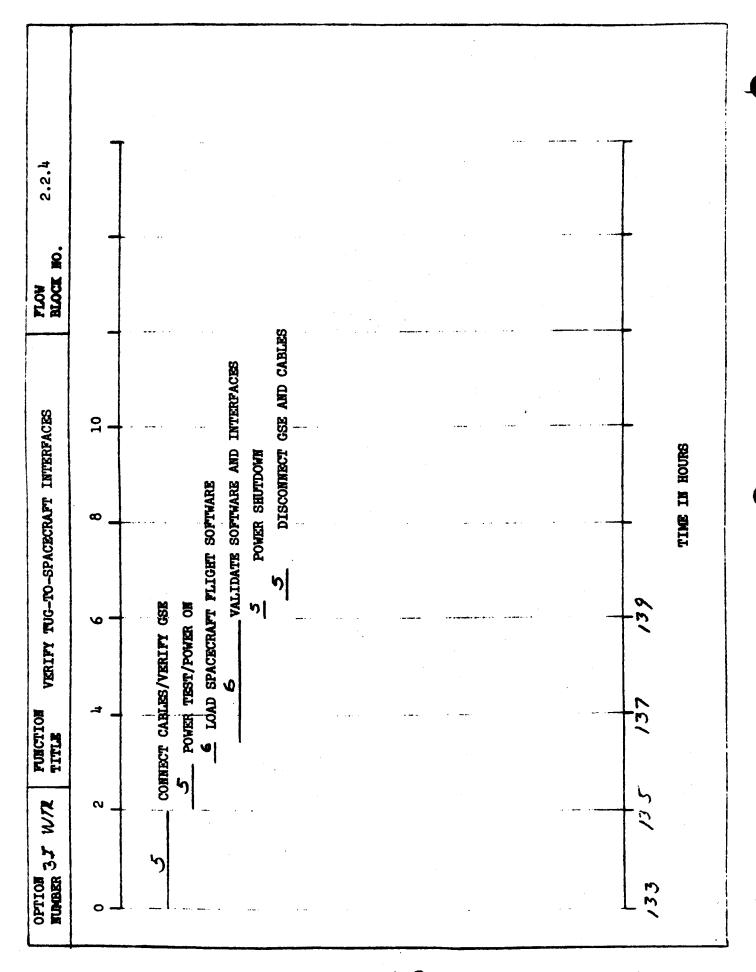
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)r transport	4	PANKLS	CTIVE COVER	CLEAR AREA AND ROOK UP TO PRIME MOVER				 		TIME IN HOURS
PREPARE FOR	2 3	CLOSE AND SECURE ACCESS PANELS	INSTALL TUG PROTECTIVE COVER	4 CLEAR AREA II				  - - 	+	
WIR TITLE	-		4	-					124	
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TRANSPORT TUG FROM TPF (C	1 (3	OR PPF) TO PRELAUNCH AREA  IN PRELAUMCH AREA AND REMOVE TUG PROTECTION COVER	6 7 1 1. I I I I I I I I I I I I I I I I I	<b>∞ T</b>
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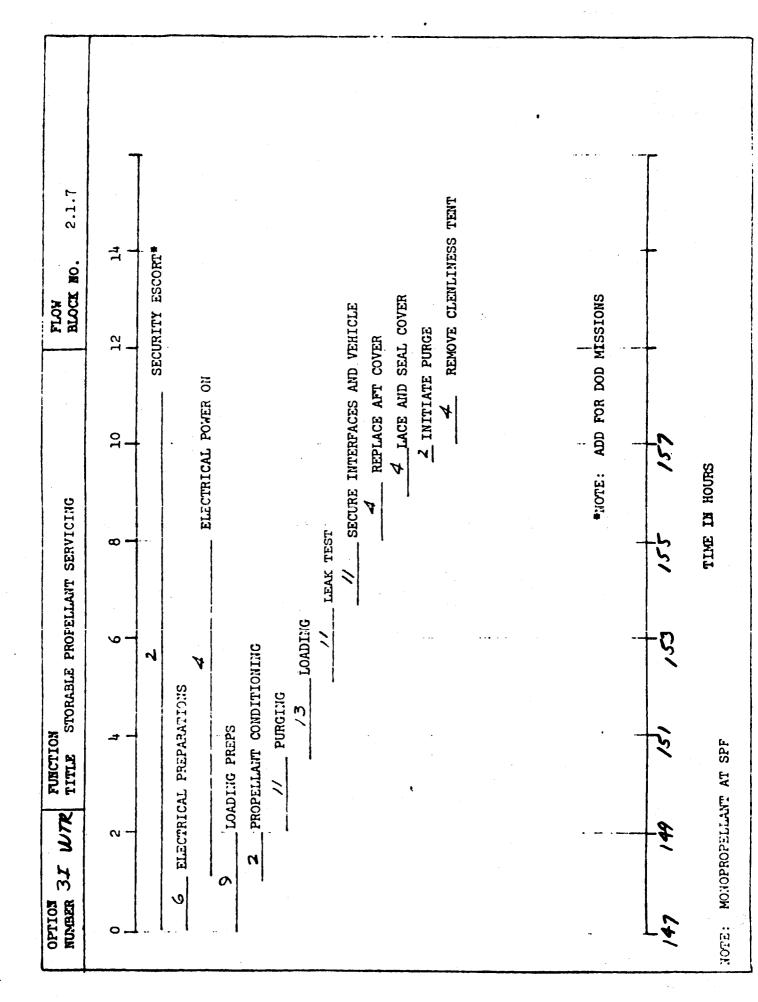


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RLOCK NO.	9						RANSPORT	COMSEC AND CONSOLE	SECURE TRANSPORT				
	<b>S</b>	<del></del>		RANSPORT	TRANSFIER SERVICE PANEL TO WORK POSITION	LAND SERVICE PANEL INTO TRANSPORT  2 TRANSFER LOX DIMP INTERFACE	LOAD LOX DUMP I/F INTO TRANSPORT	4 TOAD CONSEC AND CONSOLE	1			70	2
PKIR FROM MAR	<b>4</b>	••••	POSITION MSPORT	LOAD FLIGHT UMBILICALS INTO TRANSPORT	SERVICE PANEL	SERVICE PANE.	2 LOAD LA	4 T	•			+	TIME IN HOURS
RECRIVE PSR		TRANSPORT	TRANSFER GSE UMBILICALS TO WORK POSITION  1 LOAD GSE UMBILICALS INTO TRANSPORT	LOAD FLIGHT UMBI	1	2 KNAD				 		+	957
TITLE	- 5	PREPARE AREA AND GSE TRANSPORT	GSE UMBILLIC	1 '	4				··•·			100	2
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2.2.5										LOCK					
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	~-					LIFT CENTER COVER AND DRAPE	LIFT FORWARD COVER AND DRAPE	LIFT AFT COVER AND DRAPE	4 LACE COVERS			<b></b> .		-Z	HOURS
NESS	.a −	Z COUNTIER	TRANSPORTER	NES	COVERS	LIFT CENTE	S LIFT	8)				·		 161	TIME IN HOURS
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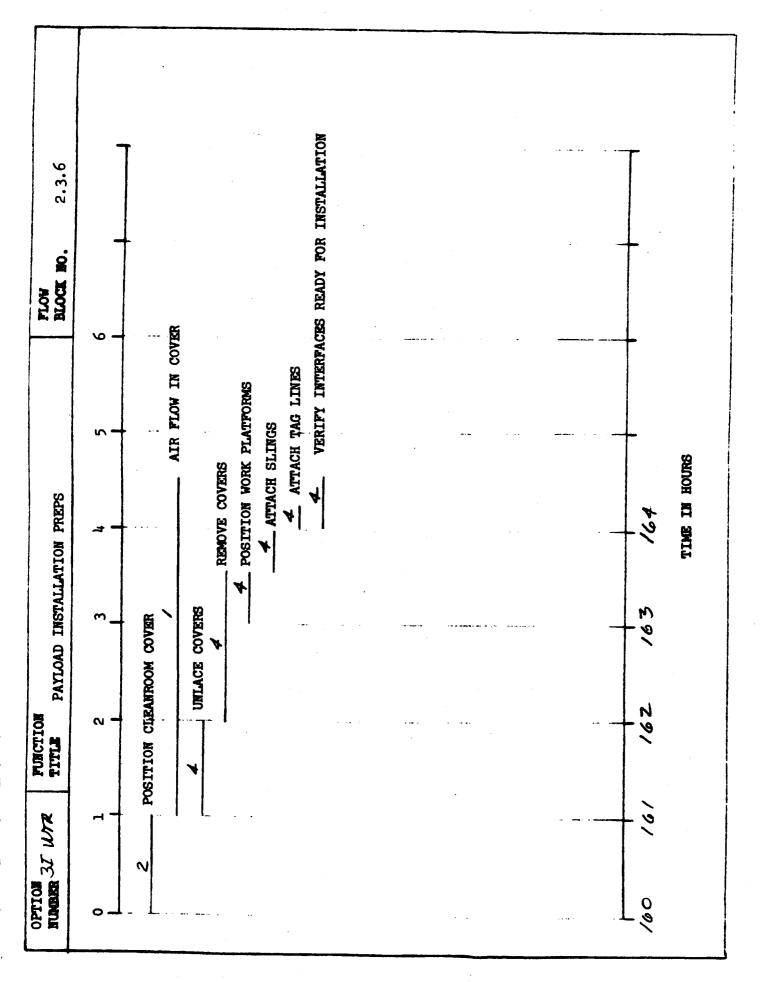
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4	• • / •			NSPORTER POSTUTON CLEANLINESS TENT	INITIATE FLOW				*Note:		 147	TIME IN HOURS
m <del>-</del>	AND VERIFY	ND CLEAR AREA	TO SPF	FOSITION TRANSPORTER  POSITION	1	4			• • • • • • • • • • • • • • • • • • • •		146	
2 -	INTERFACE	INITIATE PURGE	TRANSFER TO SPF			Ģ	4	 -			 145	
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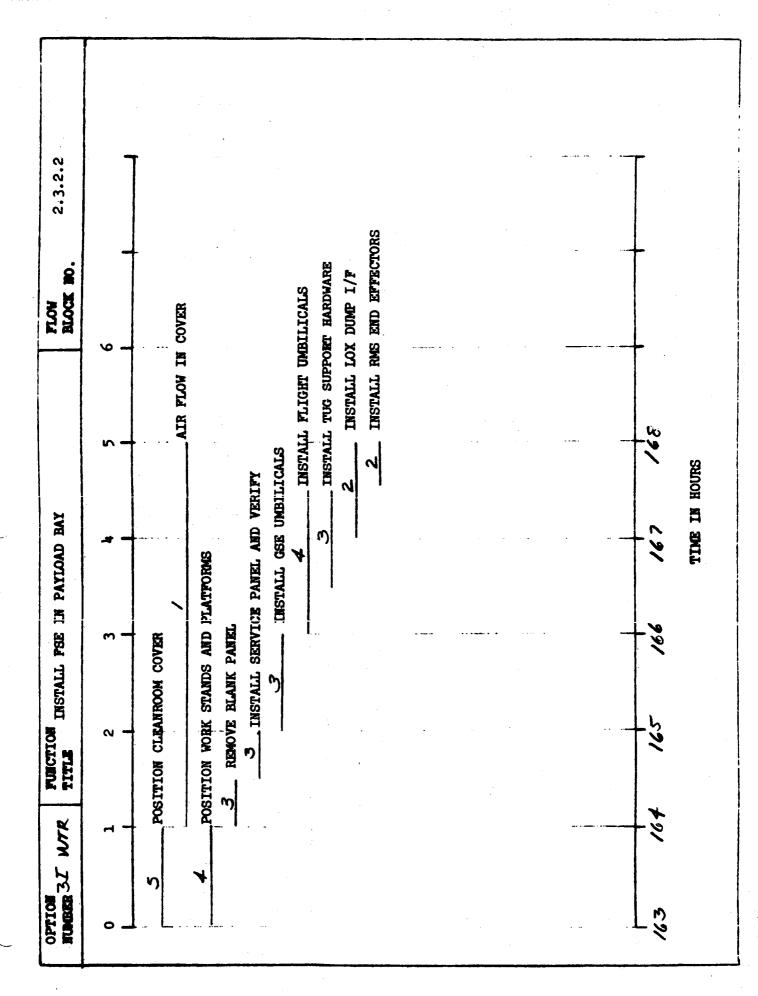


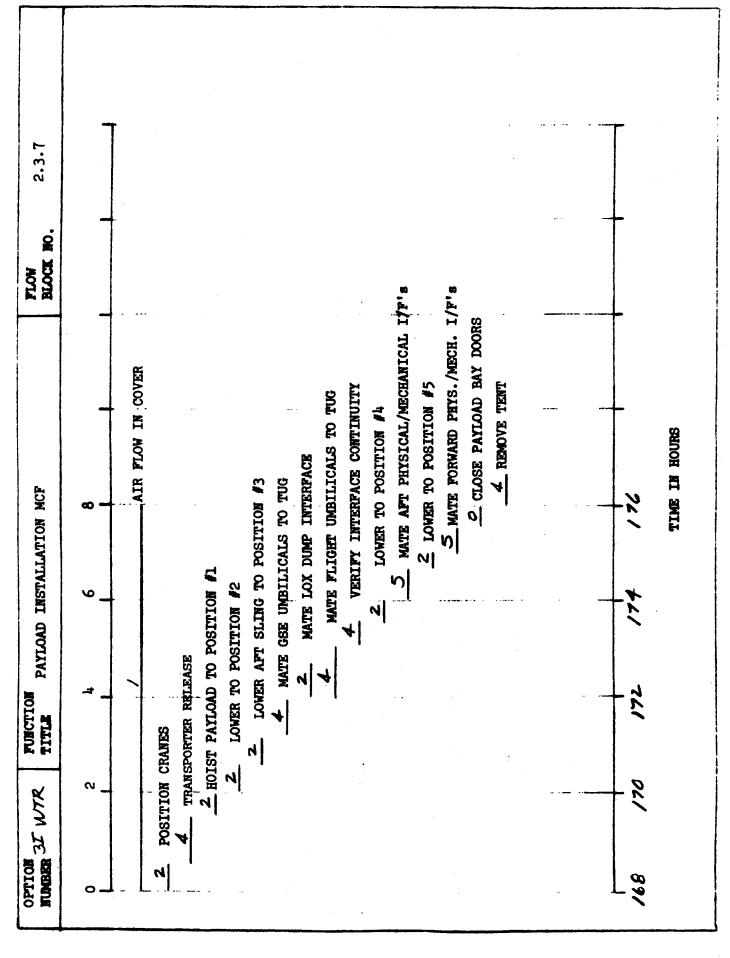
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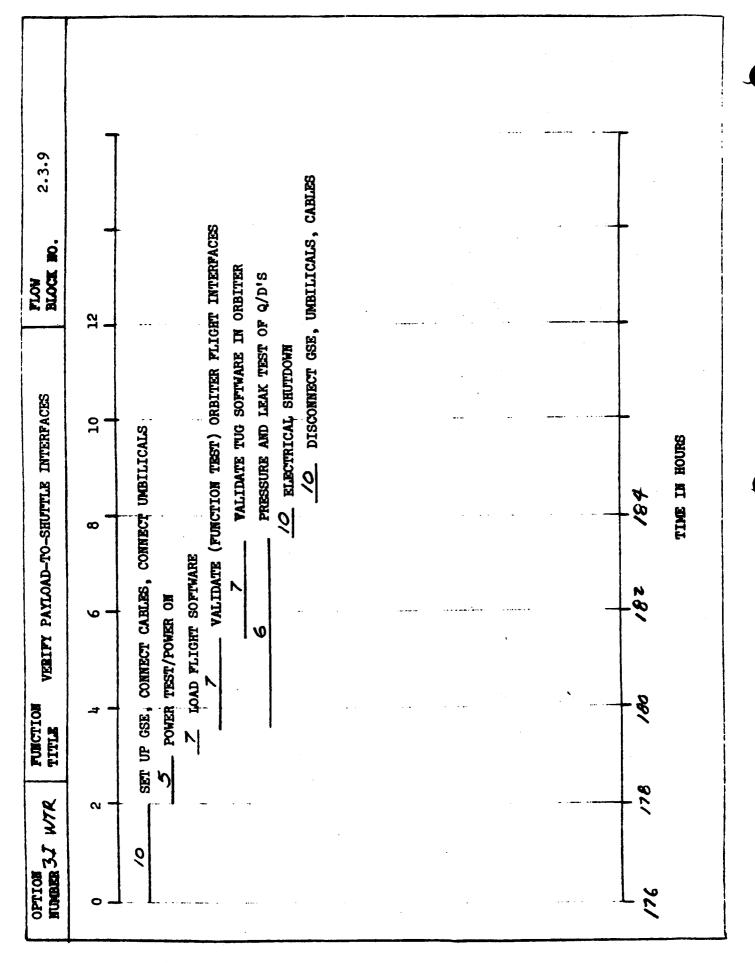
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	5 4			TH MOTE AT ORRITHER AREA	PAYLOAD BAY CLEAN COVER	FOR UNLOADING FSE			*NOTE: ADD FOR DOD MISSIONS		/チケ TIME IN HOURS
	e –	* E		MSPORT		PREPS				,	441
TITLE	1 2	SECURITY ESCORT	TRANSPORT CLEAR AREA	TRANSPORT TO MCF		<b>6</b>		 			42 143
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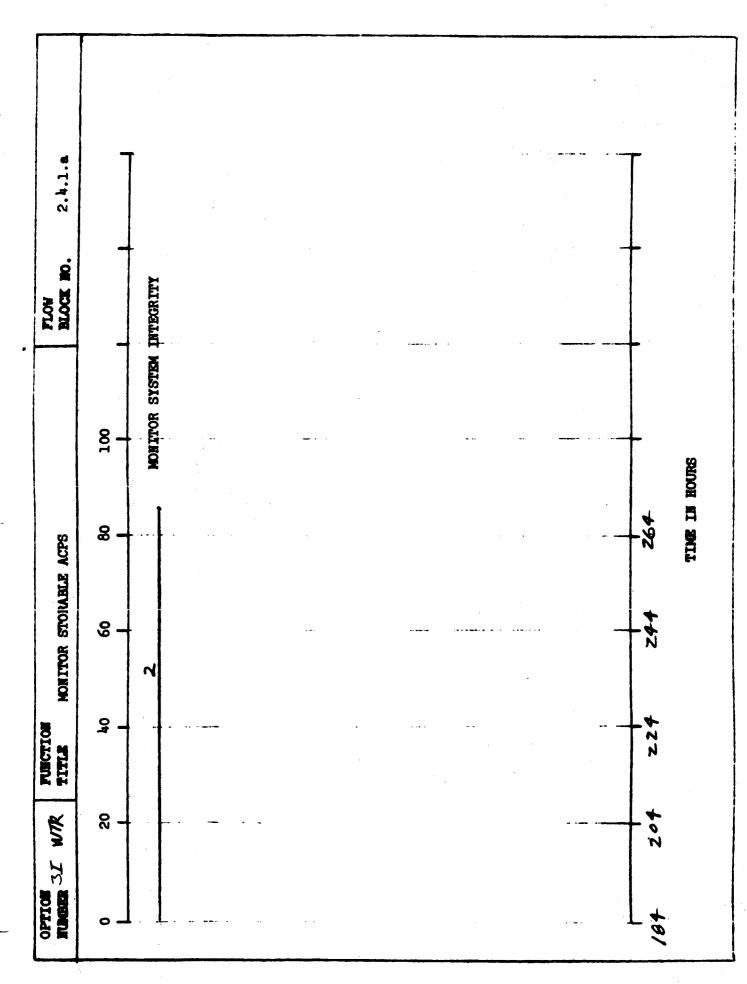
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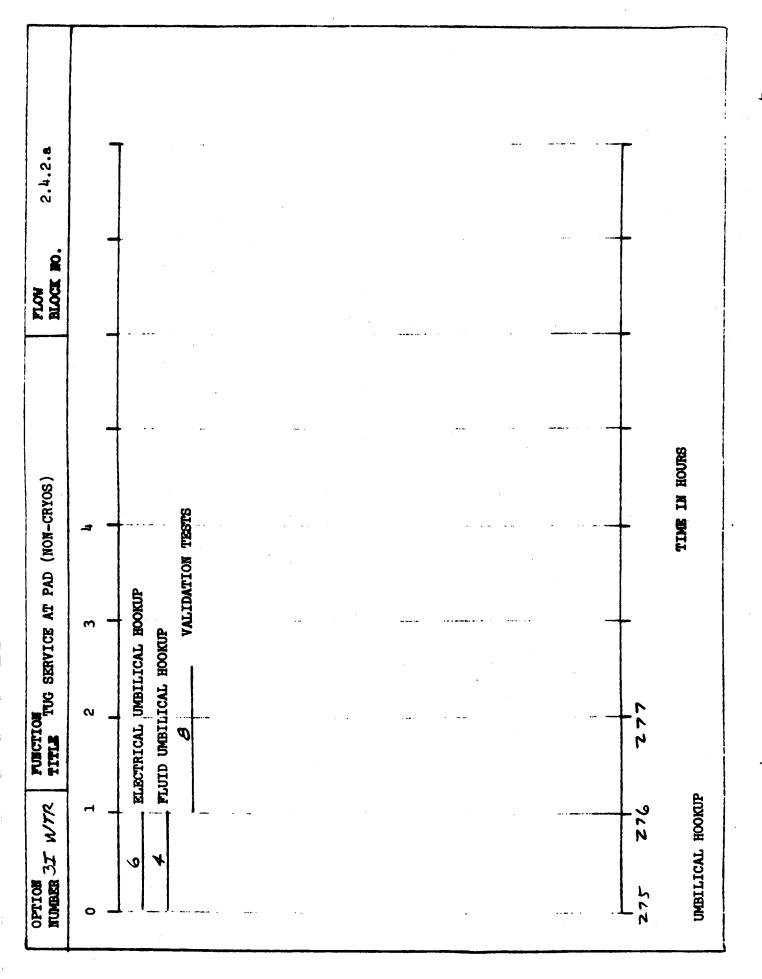






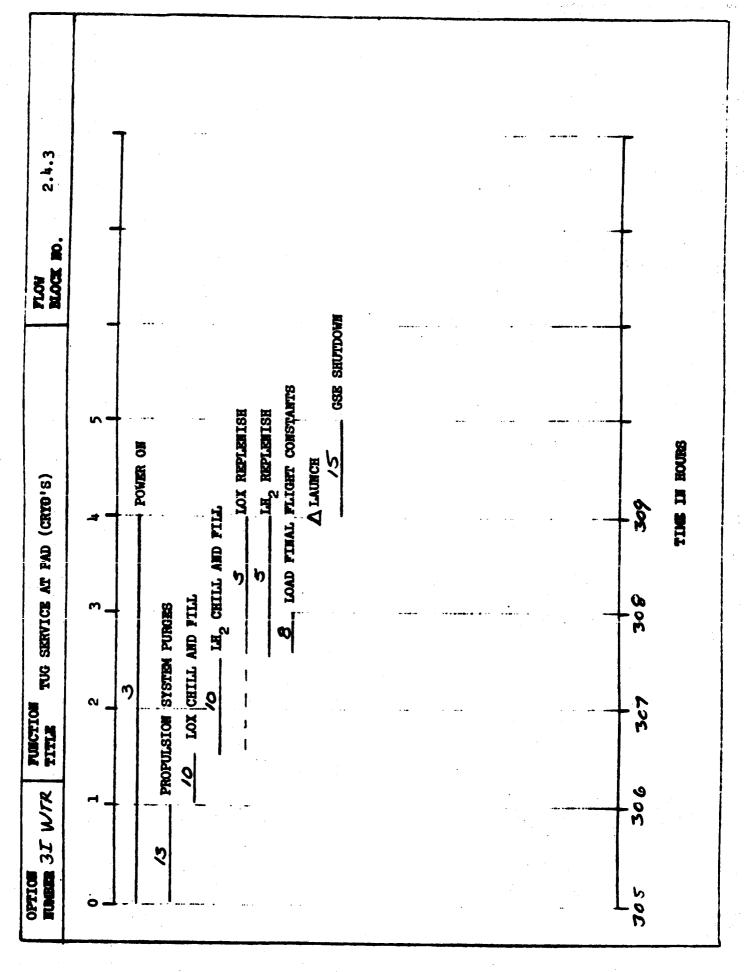


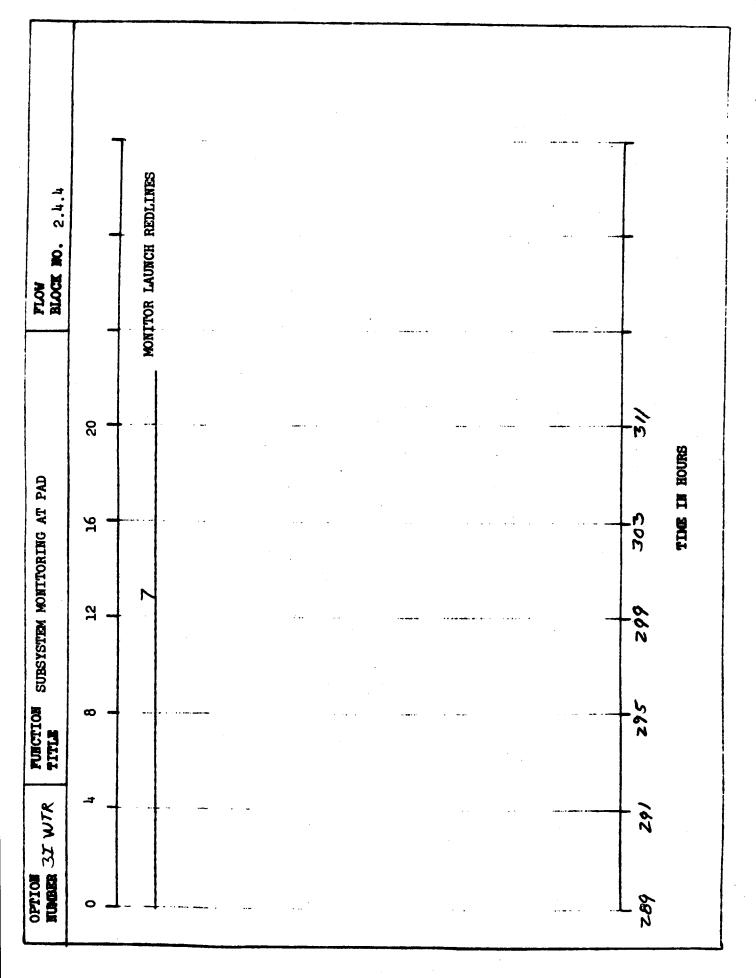




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SYSTEM TEST	10		POWER ON		SIMULATED FLIGHT TEST  7 POWER DOWN							<b>22</b>
ORBITER/PAYLOAD INTEGRATION SYSTEM TEST	æ <del>-</del>			PRESSURE TEST Q/D'S DIAL SOFTWARE	SIMULATI		. •		· ····································		786	TIME IN HOURS
ORBITER/PAYLO	9	GROUND KLECTRICAL HOOKUP PNEUMATIC AND LIQUID HOOKUP	<b>6</b>	LOAD F	0		. We also has		· · · · · · · · · · · · · · · · · · ·	_	182	
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TASK TIMELINES

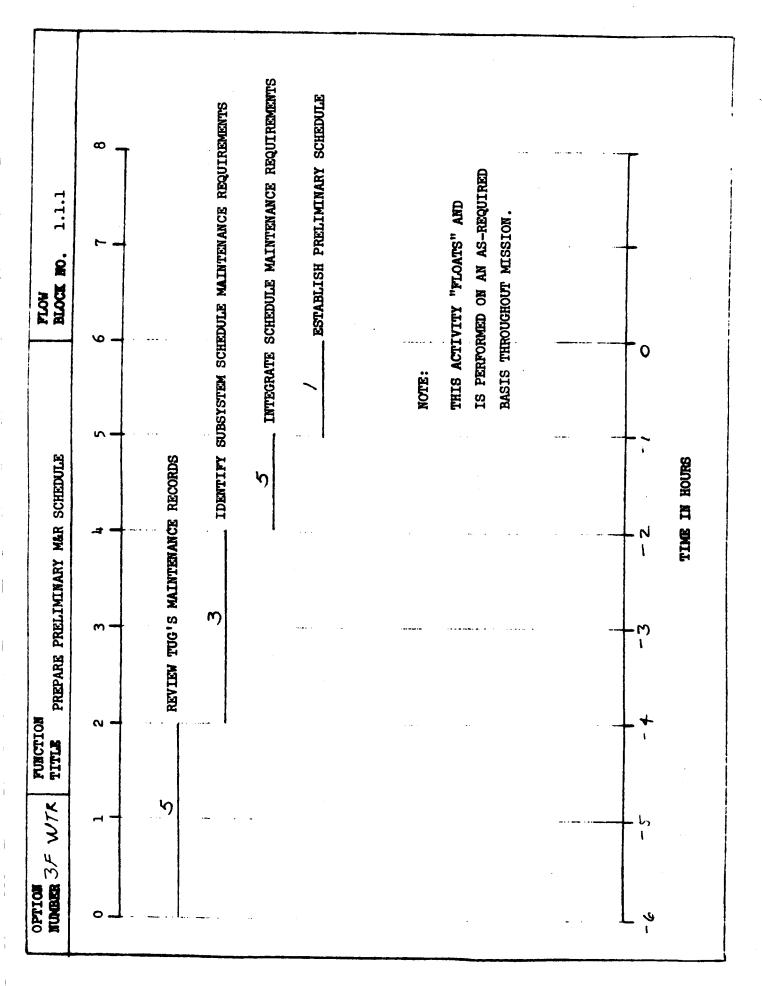
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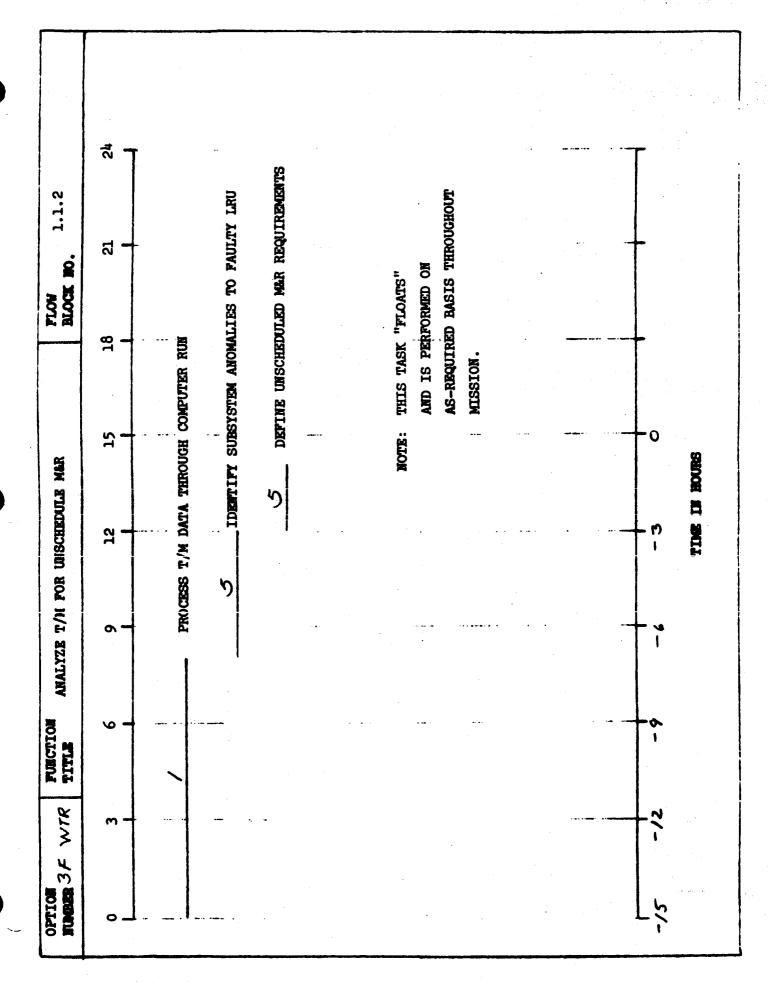
THE CRYOGENIC TUG

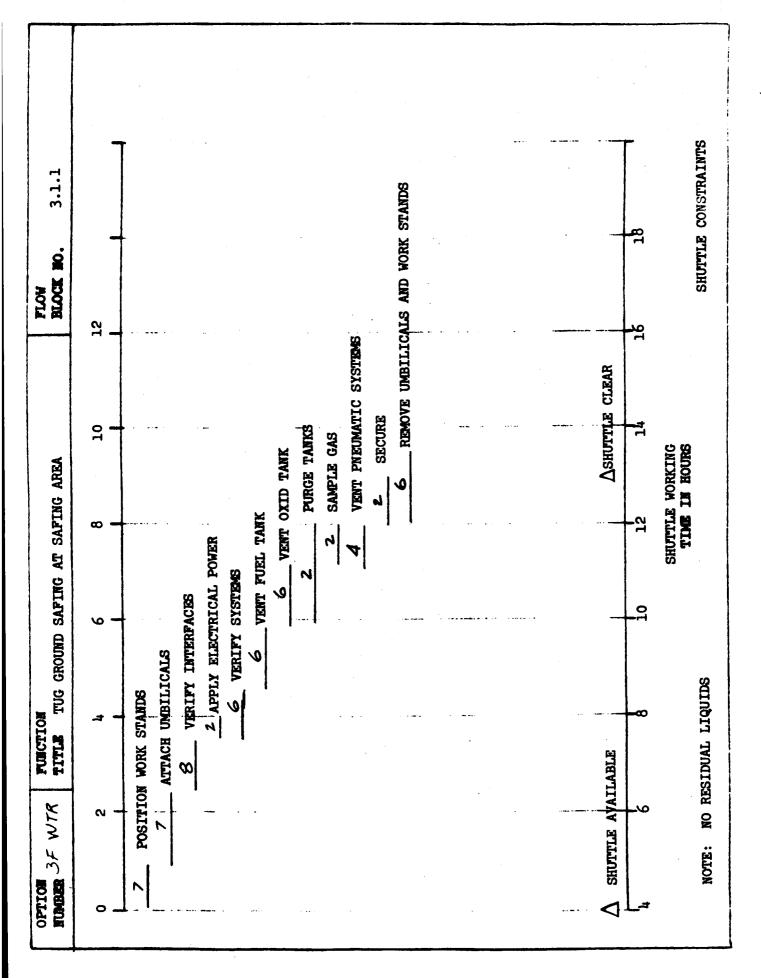
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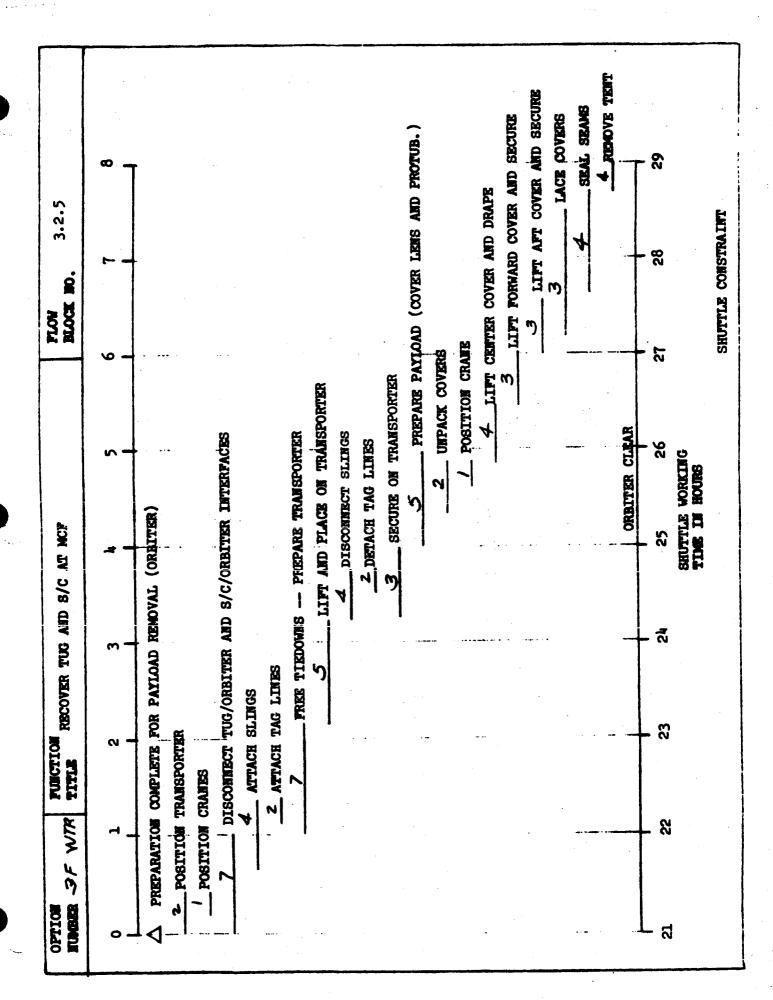
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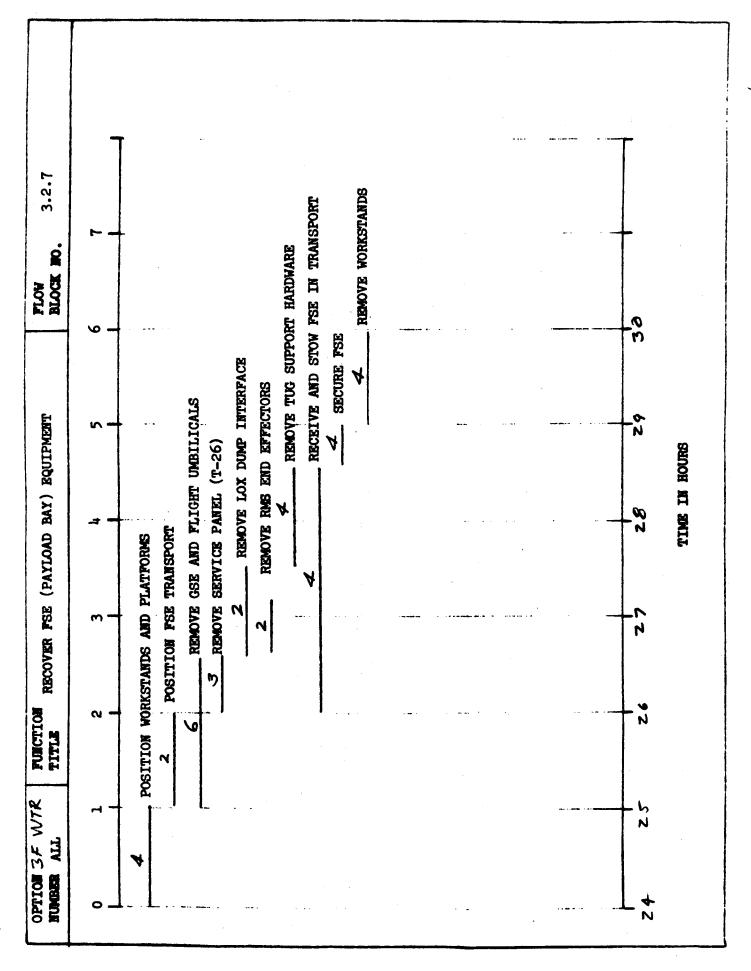
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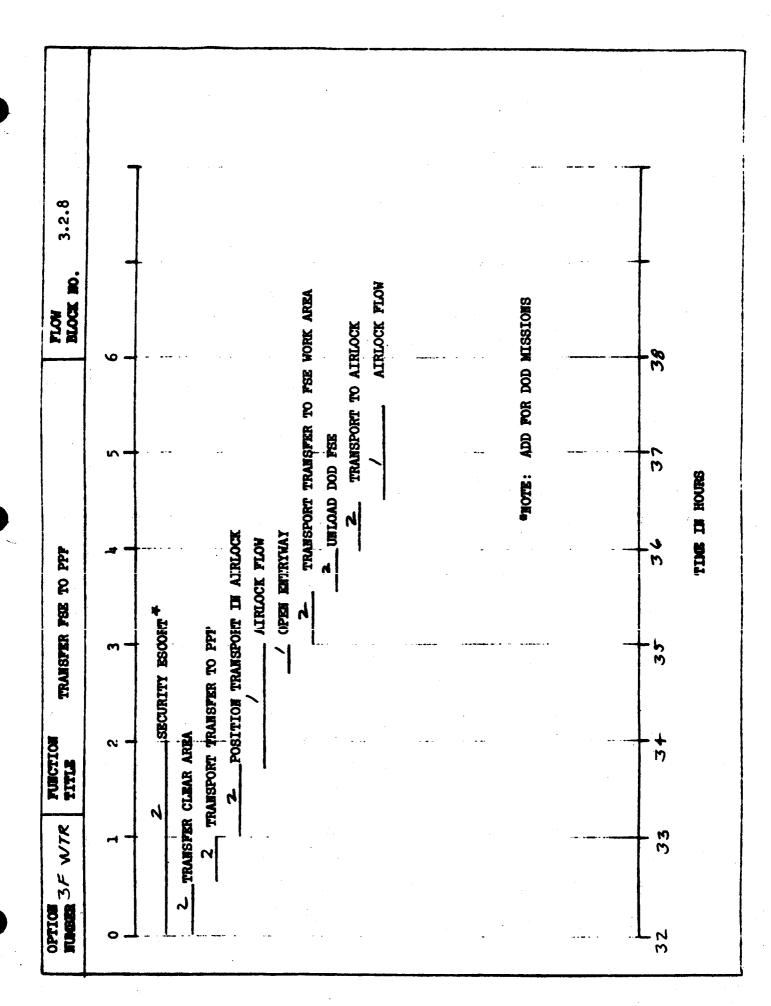


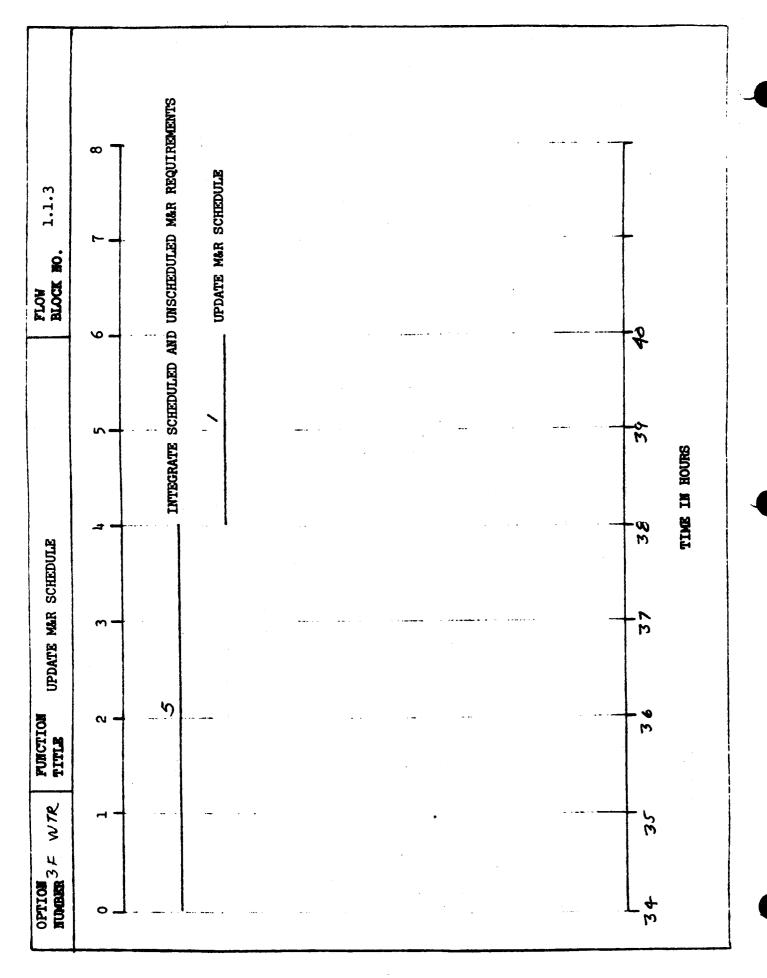




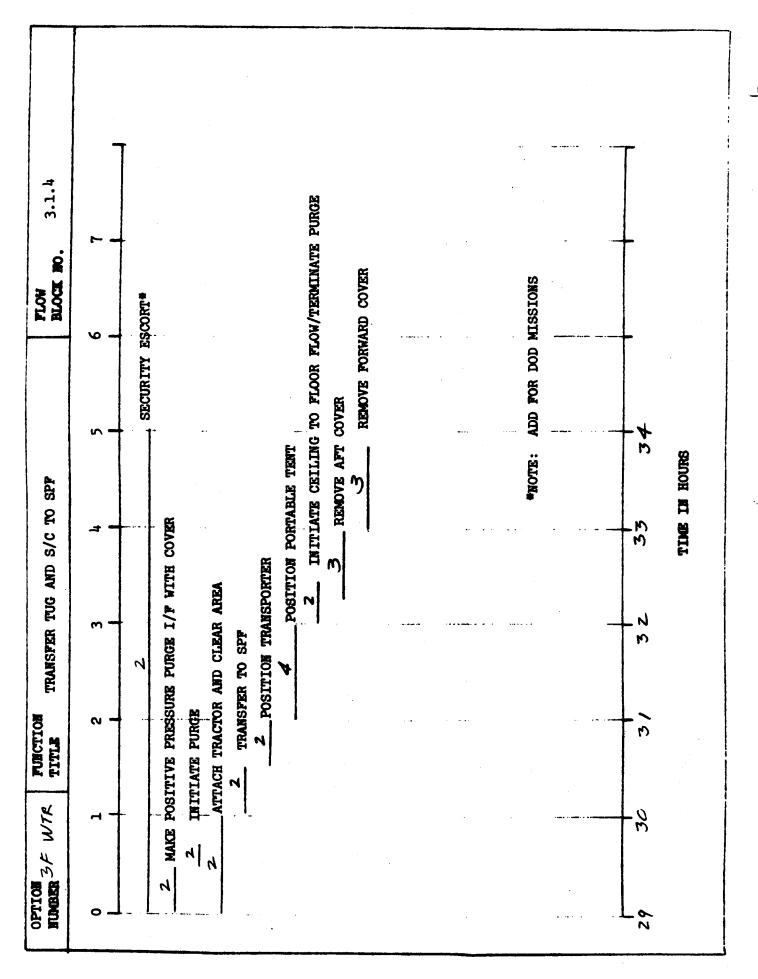


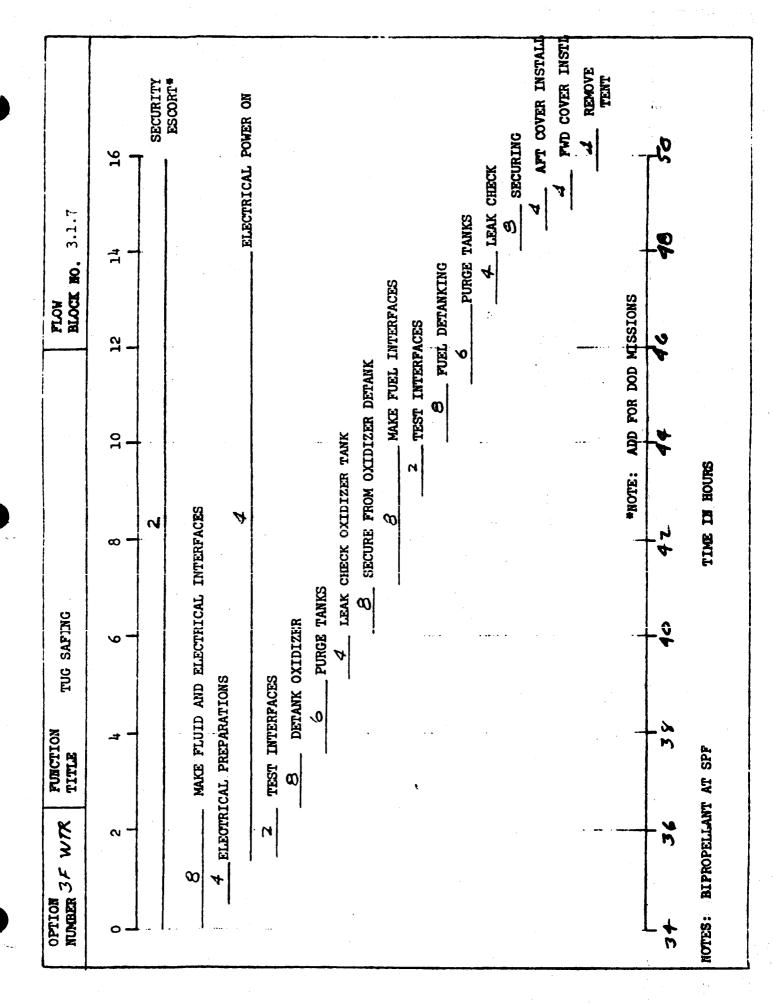


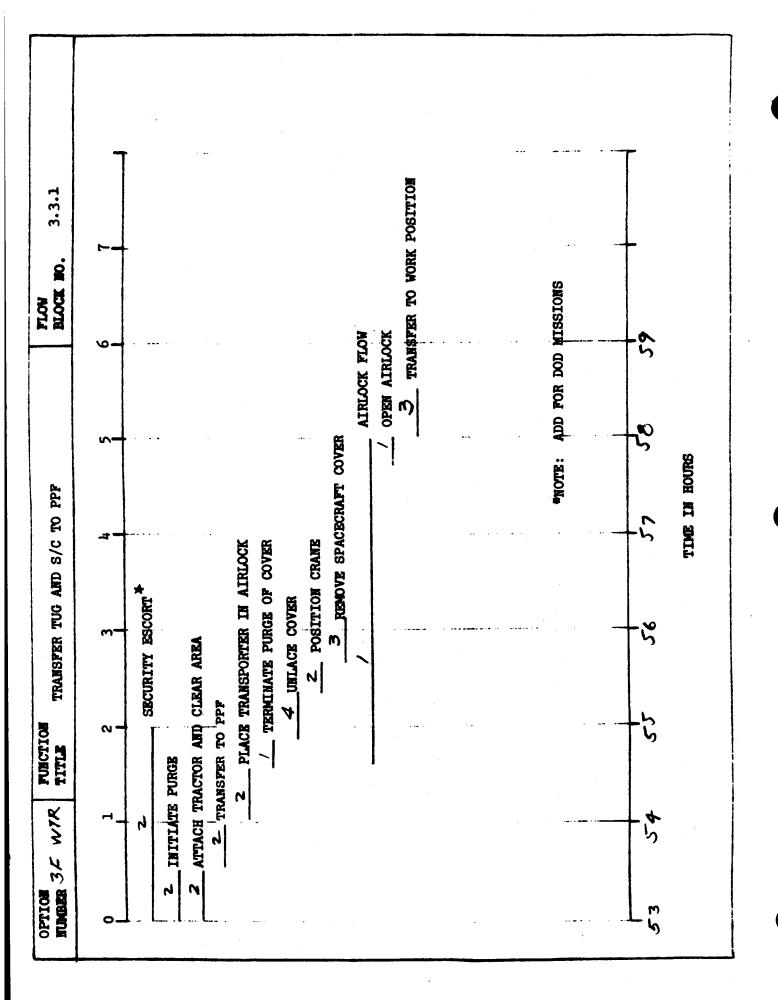




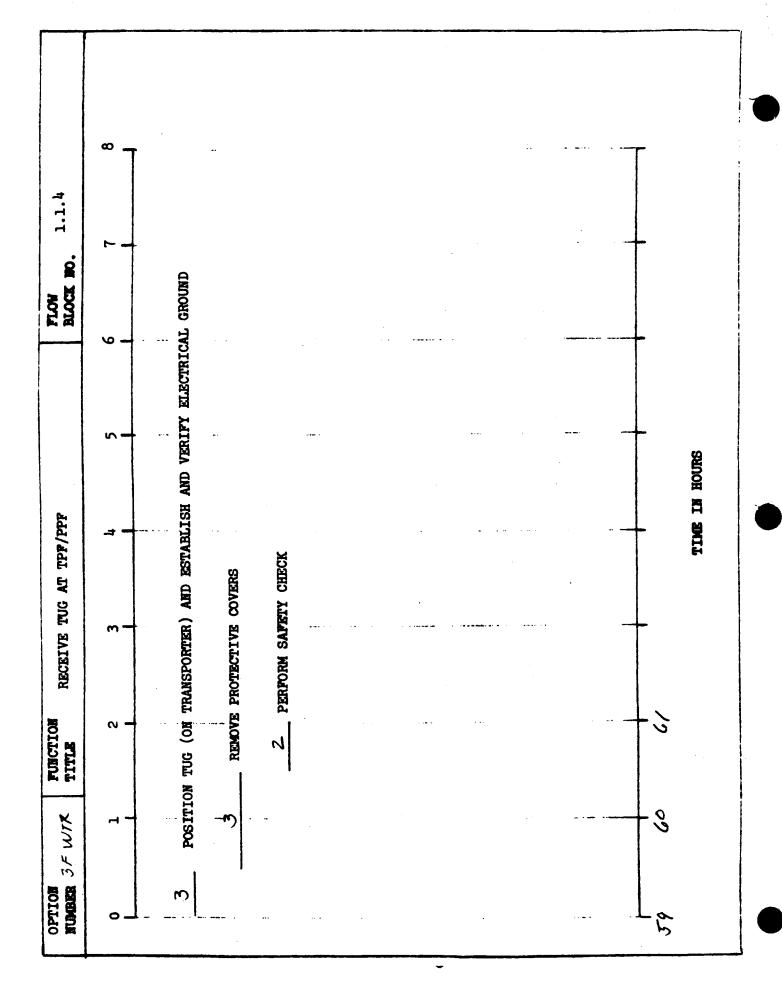
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PLOW BLOCK NO.	7 9							•		-	
	s <del>-</del>			AREA	·			- <del>-</del>	· · ·		
At TPF/PPF	7			APPROPRIATE WORK AREA		·	,		·		Time in hours
RECEIVE FSE AT 1	3		TUGS FOR PSE	TRANSFER FSE TO AF	•••						
TITLE R	8 -	RY PSE	PREPARE ROUTING TUGS FOR F	3 TRA		or •■ •				\$	
NUMBER 3F WTR		3 INVENTORY PSE	PRE							37	
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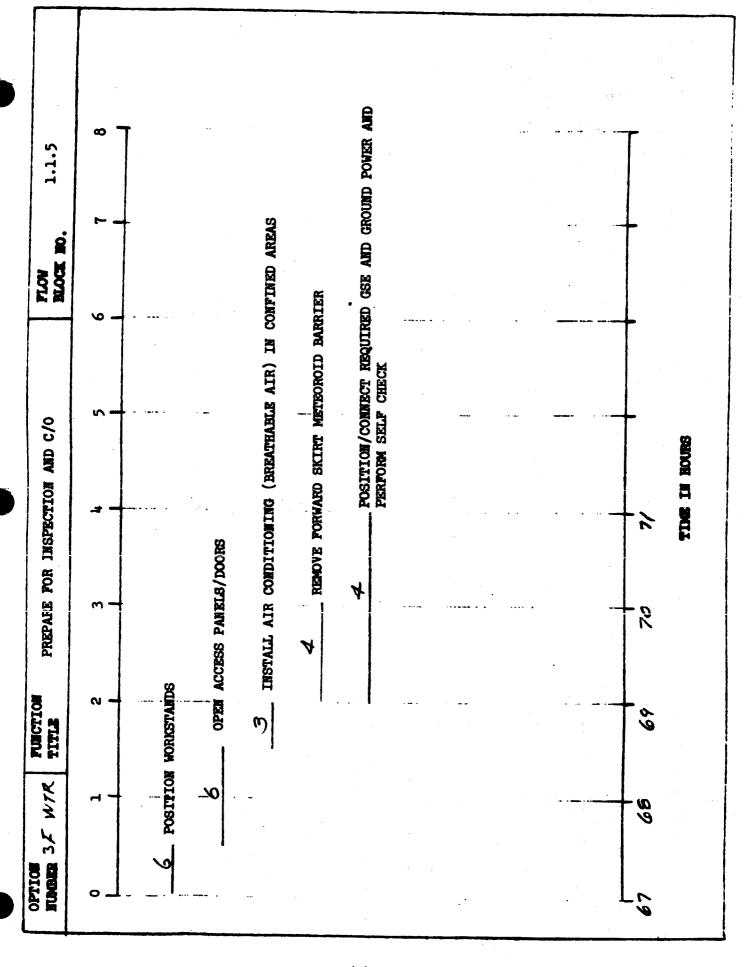


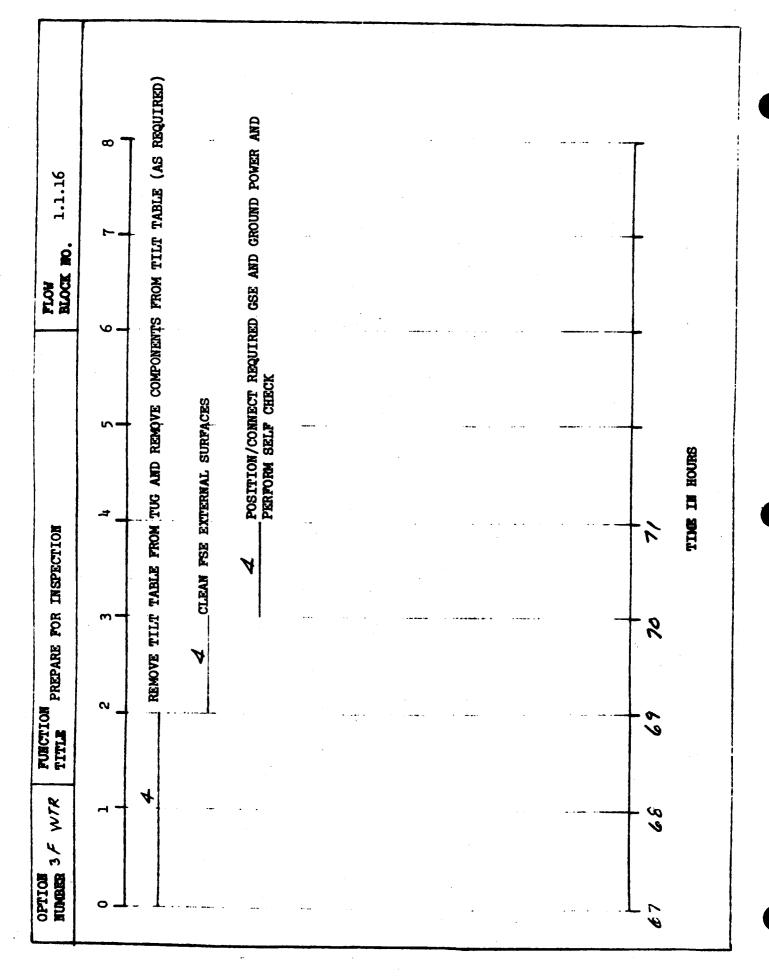




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3.3.7	<b>-</b> -	•							TOW	D TUG COVER				+	
FLOW BLOCK NO.	9 -					MENT	ORK STANDS TRANSFER TUG TO AIRLOCK	OPEN CLEANROOM ENTRYWAY	AIRLO CK FLOW	INSTALL FORWARD TUG COVER		•		20	
	2	•••		. ••		REMOVE SPACECRAFF EQUIPMENT	REMOVE WORK STANDS	OPEN CLEANT	2 POST#TO	- 1	•••• ·		<u></u>	29	BOURS
DEMATE TUG AND SPACECRAFT		·		NT AND TUG	SPER SPACECRAFT	REMOVE SP.	A REMOV						<u>-</u>	65	TIME IN HOURS
DEMATE TUG A	m <b>-</b>	TAND	RAFT SLING(S)	: DEMATE SPACIECRAFT AND TUG	3 TRAIISF	7	••••							,	
FUNCTION	~ _	POSITION KND WORK STAND	ATTACH SPACECRAPT SLING	POSITION CRANE						• • • • • • • • • • • • • • • • • • •				19	
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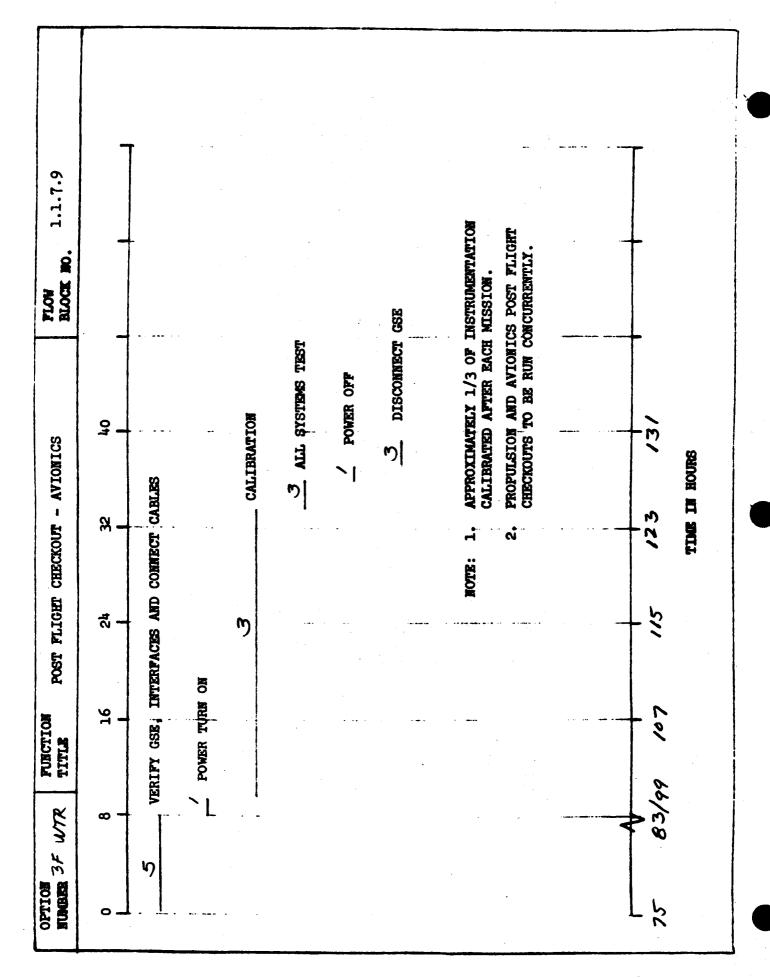




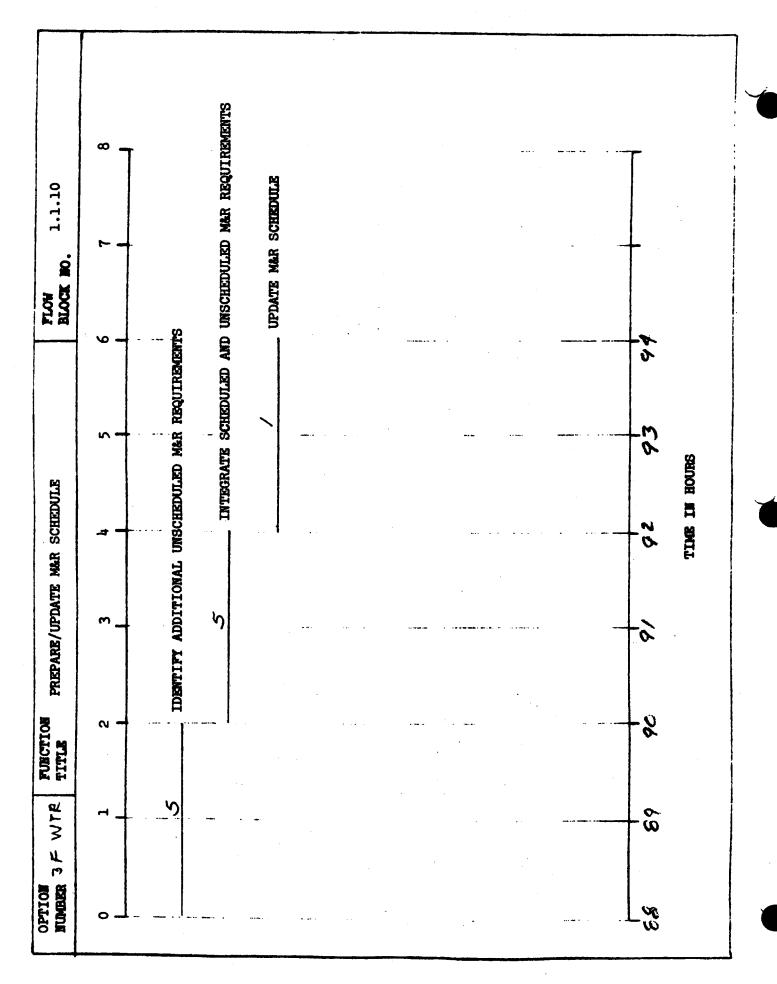
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MOCK W	12	CHANICAL SI	BSYSTEM	SYSTEM	SCREPANCIES					***************************************		,	
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POST FLIGHT RECEIVING INSPECTION	7	INSPECT STRUCTURES/MECHANICAL SUBSYSTEM	INSPECT PROPULSION SUBSISTEM	INSPECT AV	DOCUMENT SU	•			• •	-			TIME IN HOURS
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1.1.17	<b>₹</b>					HARDWARE							<b>.</b> .		_		
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FSE POST FLIGHT/RECEIVING INSPECTION	8 -		AND WARRING INTERPACE EQUIPMENT	INSPECT FIUID UMBILICALS	INSPECT ELECTRICAL UMBILICALS	_INSPECT TUG SUPPORT ATTACHMENT HARDWARE	DOCUMENT FOR DISCREPANCIES			-	. <b>.</b> .		•		-/8	TIME IN HOURS	
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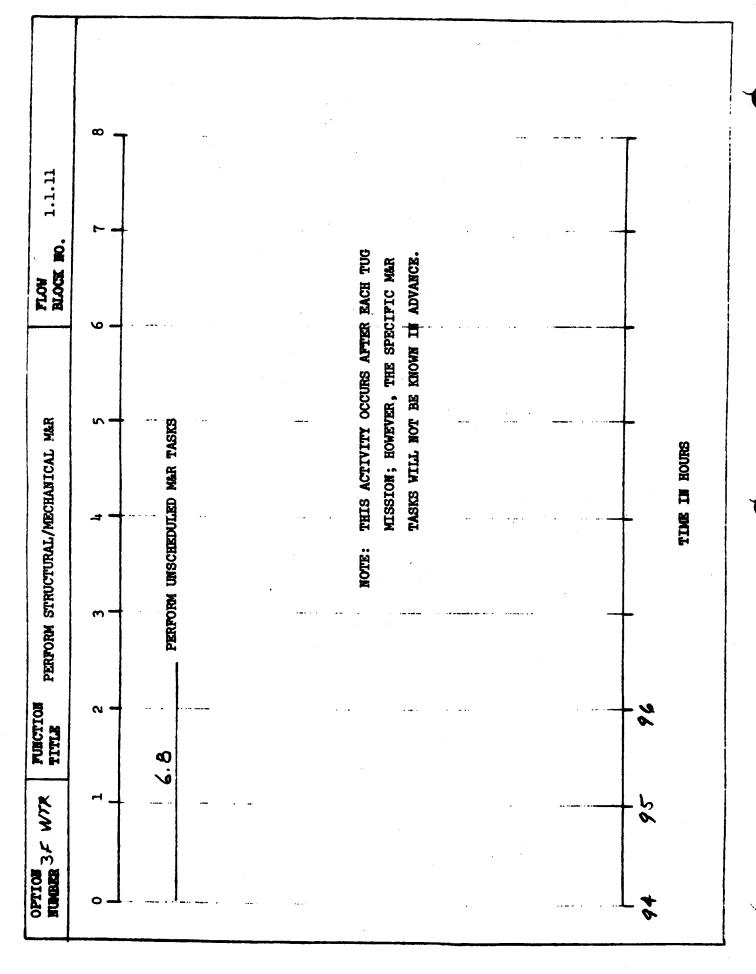
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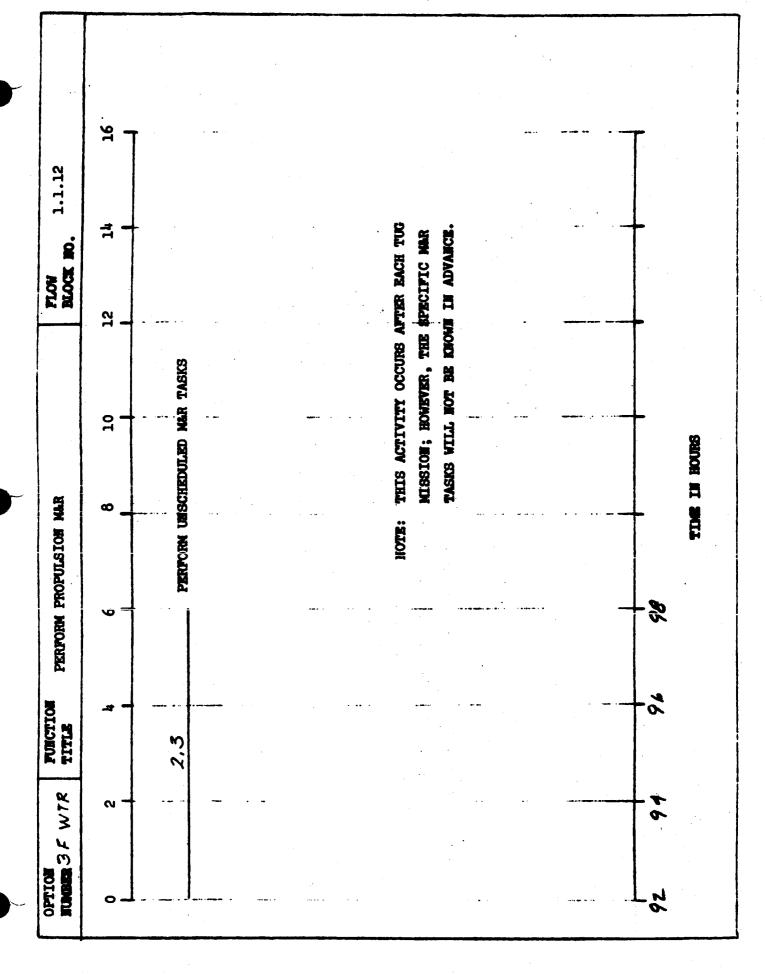


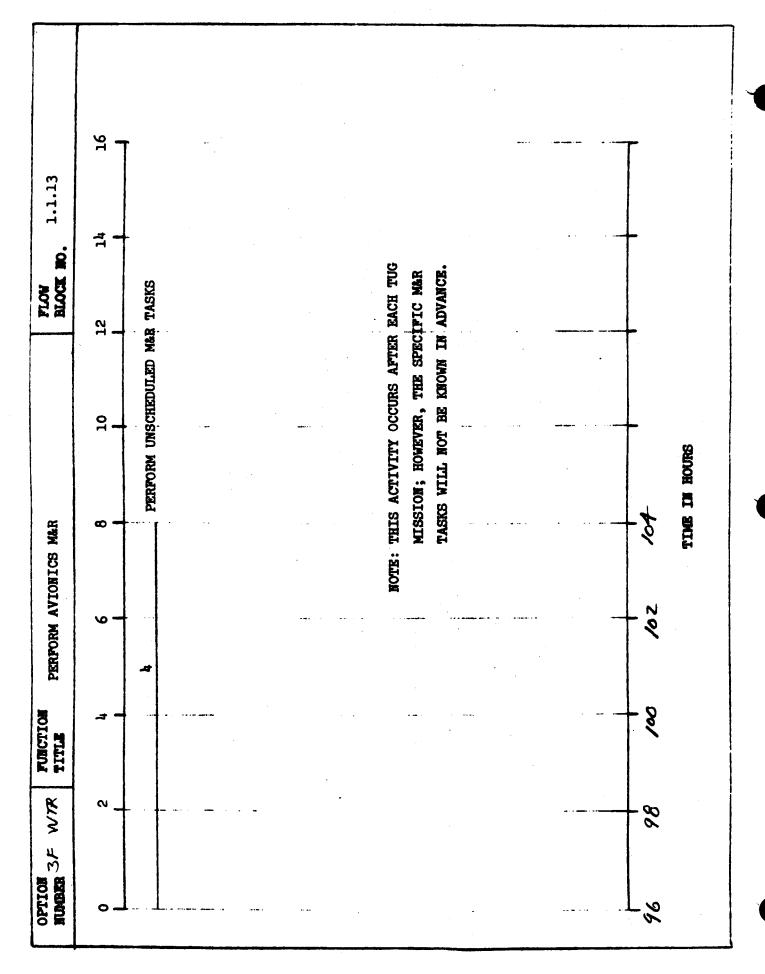
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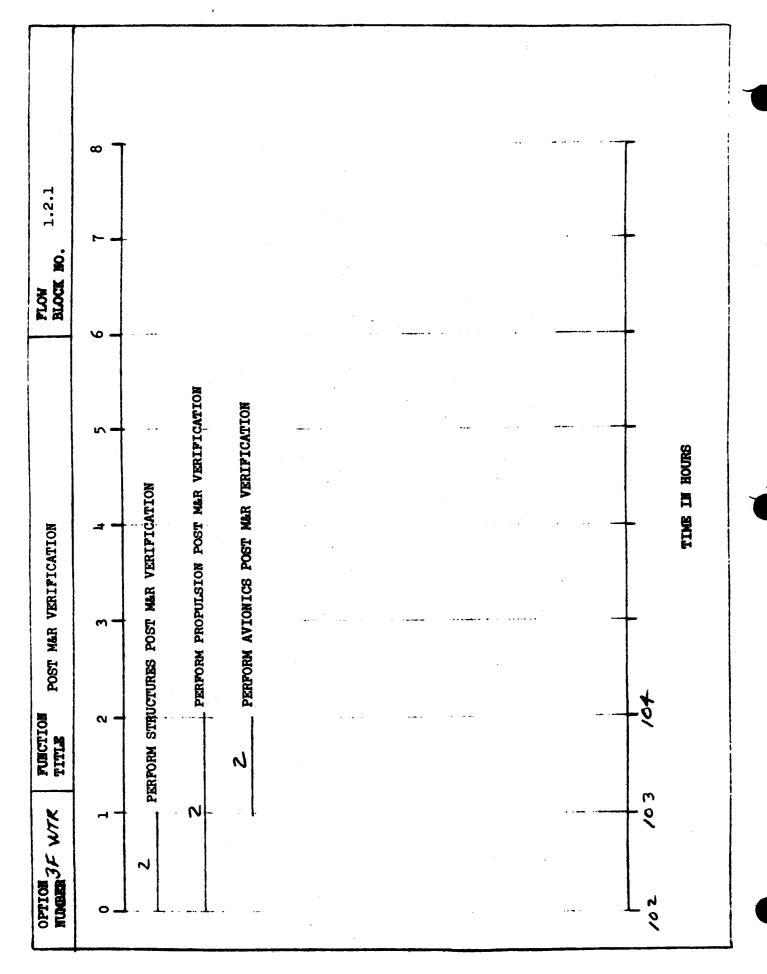
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	50	PERFORM UNSCHEDULED STRUCTURAL/MECHANICAL MAR	PERFORM UNSCHEDULED AVIONICS MAR	PERFORM UNSCHEDULED PROPULSION MAR	CLEAN AND PACKAGE FLUID UNBILLICALS		THIS ACTIVITY OCCURS AFTER EACH TUG MISSION; HOWEVER, THE MACHITUDE OF INDIVIDUAL SUBSYSTEM UNSCHEDULED MAR TOGETHER WITH RELATED SKILL REQUIREMENTS WILL VARY.	en lander de la companya de la comp	7/12	TIME IN BOURS
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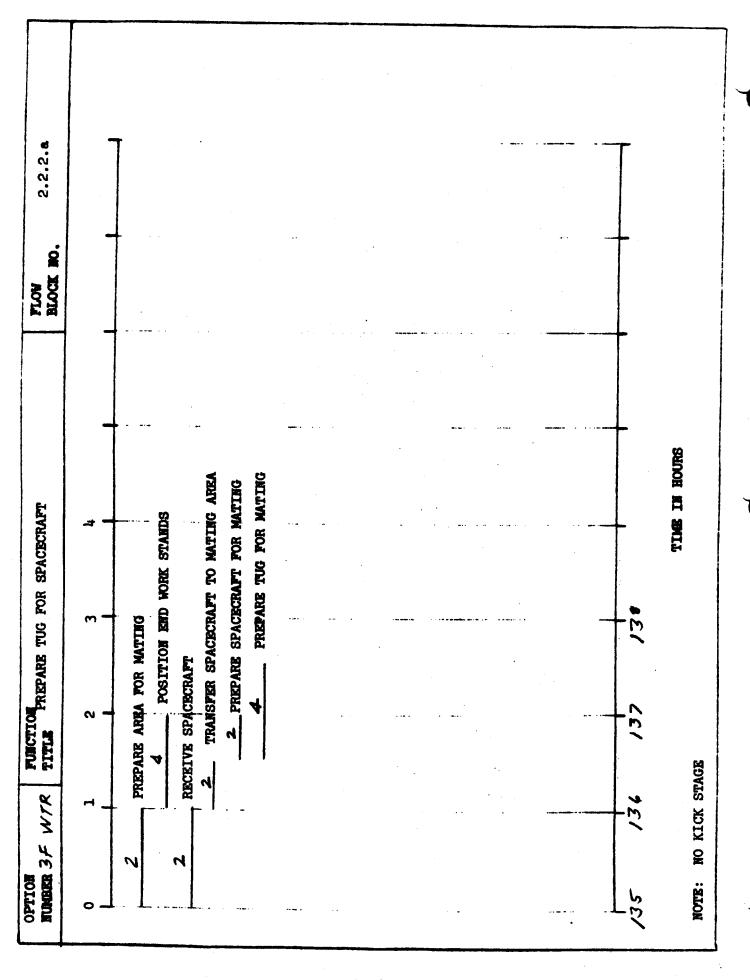
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7777	~	<b>38</b>	MOVE GSE AWAY FROM TUG			 e wew.	5 · · · · ·	· <u>-</u> -		
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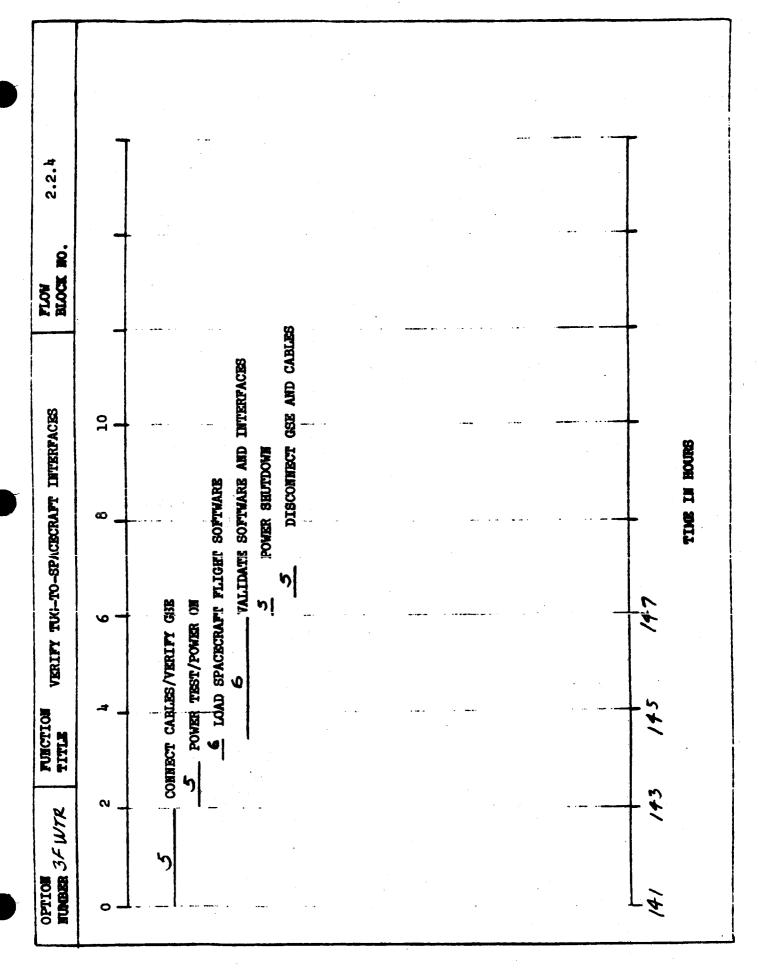
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BLOCK NO.	9	- -			NO:		<b>3</b>	O TRANSPORT	COMBEC AND CONSOLE LOAD CONSOLE	SECURE TRANSPORT				 147	
	٠.	• • • • • • • • • • • • • • • • • • •		POSITION	TRANSFER SERVICE PAREL TO WORK POSITION	LOAD SERVICE PANEL INTO TRANSPORT	TRANSFER LOX DUMP INTERFACE	LOAD LOX DUMP I/F INTO TRANSPORT	4 TRANSFER COMSEC AND CONSOLE	24		<del>-</del>		 146	<b>FURS</b>
ISE PROPI MAR	.a =		SITION	IBILICALS TO WORK POSITION MARILICALS INTO TRANSPORT	SRVICE PAREL	KERVICE PAKEL	TRANSFER 10	2 LOAD LO	4 TR			<u>.</u>	•	 4	TIME IN HOURS
RECEIVE FSE FF	m_	TRANSPORT	LS to work positi Ls into transport	SFER FLIGHT UMBILIC LOAD FLIGHT UMBILI	TRANSIFER SI	2 TOAD 8	4			e es <del>que ca</del>	• • • • • •		•	 144	
PITE R	- 5	PREPARE AREA AND GSE TRANSPORT	TRANSFER GSE UMBILICALS TO WORK POSITION  1 LOAD GSE UMBILICALS INTO TRANSPORT	TRAN S	7									 143	
3F WTR	٦-	PREPARE	TRANSFER	4	-								*****	142	
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	25			٠ ـــ.		TON #2	MATING	TAG LINES			•	·	A HRS OF	   		+	,	<b>9</b>
SCIALT		<b></b>			TTION FI	TRANSFER SPACECRAFT TO POSITION #2	TUG/SPACECRAF	3 DETACH SLING AND TAG LINES	-				WOFFE. ADD					TIME IN HOURS
MATE TUG AND SPACECRAFT	m <u> </u>	ECRAFT		ATTACH TAG LINES TO SPACECRAFT	ST SPACECRAFT TO FOSTILON WATER TWINEDRAFES	TANSFER SPACE	4 COMPLETE	7		a ex allegen com		ada an e in			•	1	È	
TITE MAIL	5 -	ATTACH SLINGS TO SPACECRAFT	LANE	CH TAG LINES	_ HOIST SPACECKAFT	4	B .							•		- 9	2	
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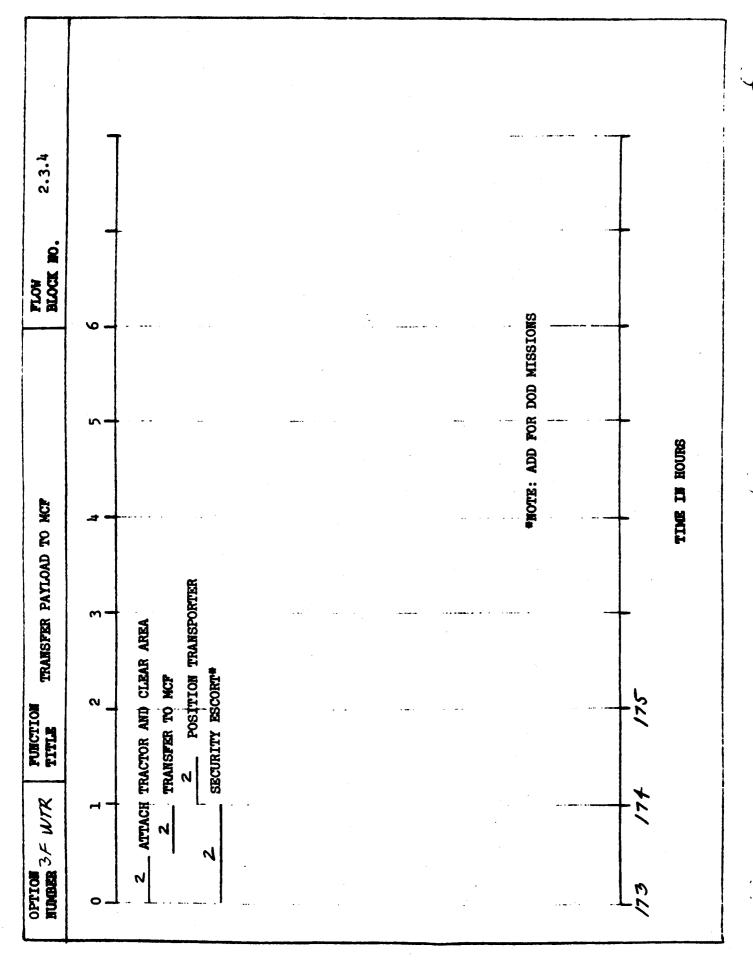


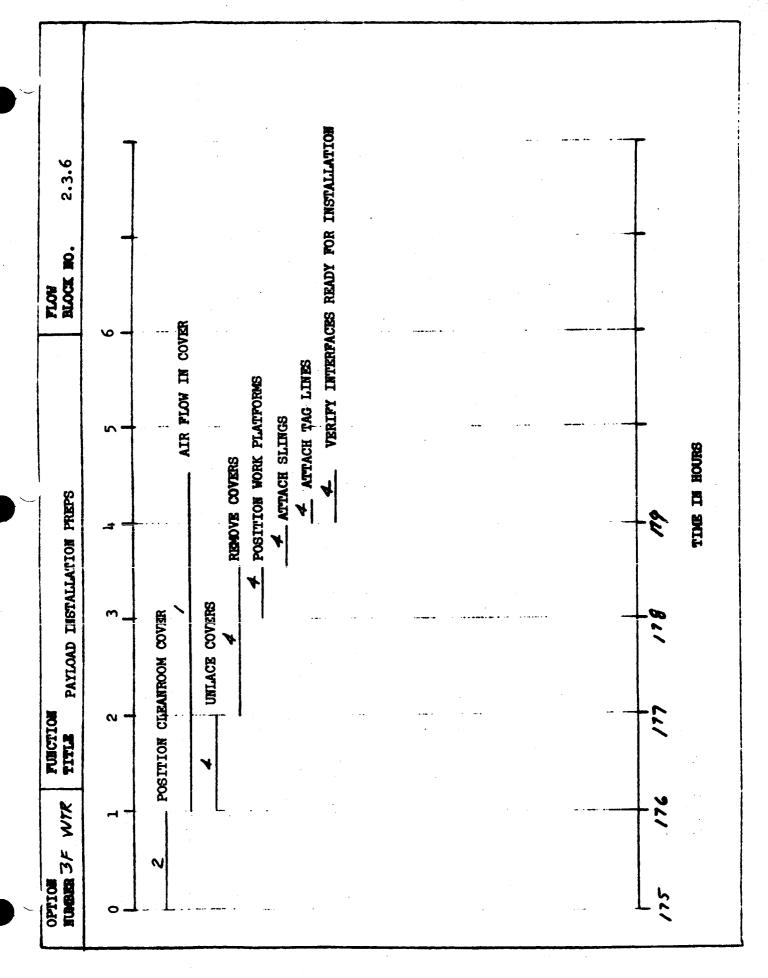
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CK NO.	<b>-</b>	•						<b>8</b>		<b>ω</b>	MOVE TO AIRLOCK		·		•		
FLOW	9 –					LAPE	AND DRAPE	ER AND DRAU	OVERS	SEAL SEAMS	G MOVE	termental en la				 151	
	· v -	• · · · ••••				LIFT CENTER COVER AND DRAPE	LIFT FORWARD COVER AND DRAPE	LIFT AFT COVER AND DRAPE	LACE COVERS	e)			nym	·	1000 allea -	 65/	URS
SS		FTER	PORTER	χ <sub>ξ</sub>	VERS	IFT CENTER (	S LIFE R	<b>a</b>	4						· ·	 50/	TIME IN HOURS
Veripy cleanliness	e –	CHECK PARTICLE COUNTER	POSITION TRANSPORTER	2 POSITION CRANES	JUNPACK COVERS	4			<u>.</u> .				·			 8+1	
FUNCTION	2 -	CH	7		- 1						• •		• • • • • • • • • • • • • • • • • • •			 147	
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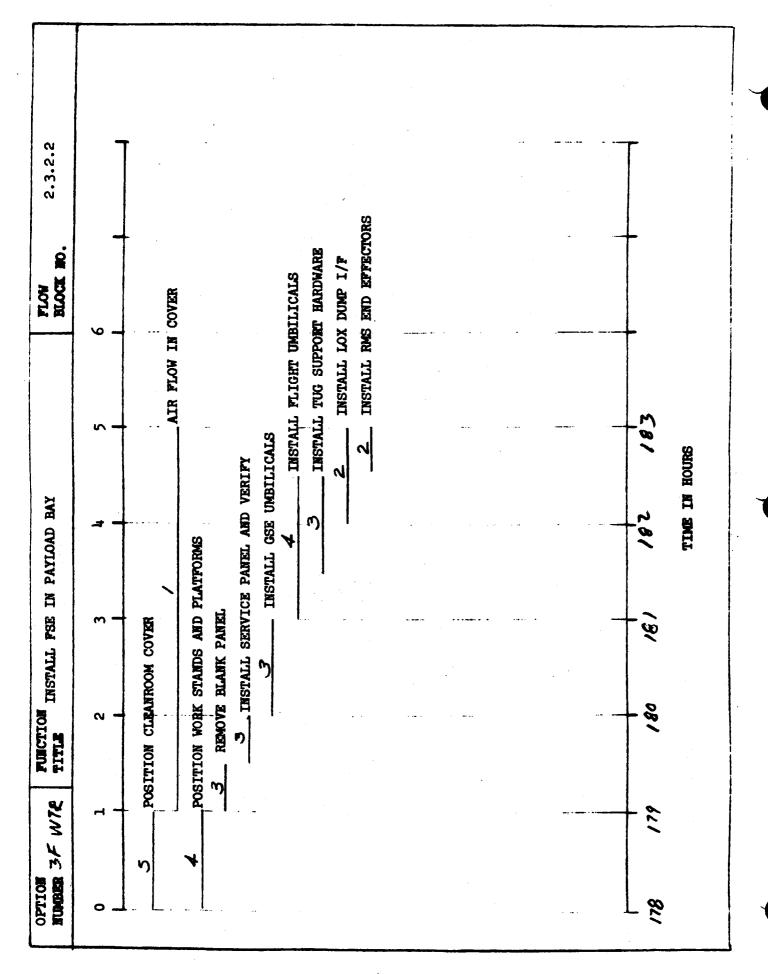
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	~	<del>.</del> .	· <del>-</del>	J.KSA.L		r cover Escort*		FOR DOD MISSIONS		· · · · · · · · · · · · · · · · · · ·		
SPF	4	· 17.		SPORTER POSTATON CLEANLINESS TENT	INITIATE FLOW	RECURITY ESCORT*		WOTE: ADD			155	TIME IN HOURS
TRANSFER PAYLOAD TO	m <b>-</b>	VERIFY	CLEAR AREA SPF	22		•	10 - 100 TB				154	
5	2	MATE PURGE INTERFACE AND VERIFY	ATTACH TRACTOR AND CLEAR AREA  Z TRANSFER TO SPF	2 POSITION		7	<del>-</del> .	·			/53	
		MATE PURGE 1	ATTACH TRACTO	•							152	
OPTION 3F WIR	0 -	2	77						·		15/	

OPTION 3F RUMBER 3F	XXX	FUNCTION BIPROPELLAWT TITLE INTEGR	I	APS LOADING AT SPF L SYSTEM	£s.	FLOW BLOCK NO.	2.1.8	
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TUC	TRAJISPO	TUG TRANSPORT TO SPR		<b>.</b>				· · · · · · · · · · · · · · · · · · ·
	REPARE T	PREPARE TUG FOR WORK						<del>-</del>
	LOAD	LOADING PREPS						
	-	FUEL CONDITIONING						
	, .	FUEL SYSTEM PURGE	RGE					
		LOAD FUEL						·
		SECURE	SECURE FROM FUEL LOADING	DADING				
			OXIDIZER LOAD	LOADING PREPS	·			
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			OXIDIZER S	OXIDIZER SYSTEM PURGE				*****
			LOAD 03	LOAD OXIDIZER				
				LEAK CHECK	LEAK CHECK FUEL AND OXIDIZER	ĸ		<del></del>
				SECURING	ING			
				PR	PREPARE TUG FOR TRAISPORT	AIISPORT		•
			···•		TRANSPORT TUG	÷		
					TUG OPERATIONS	18 1/2 HOURS		<del></del>
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155	159	163	(9/	121	1.7			
				TIME IN HOURS	Q			<del></del>

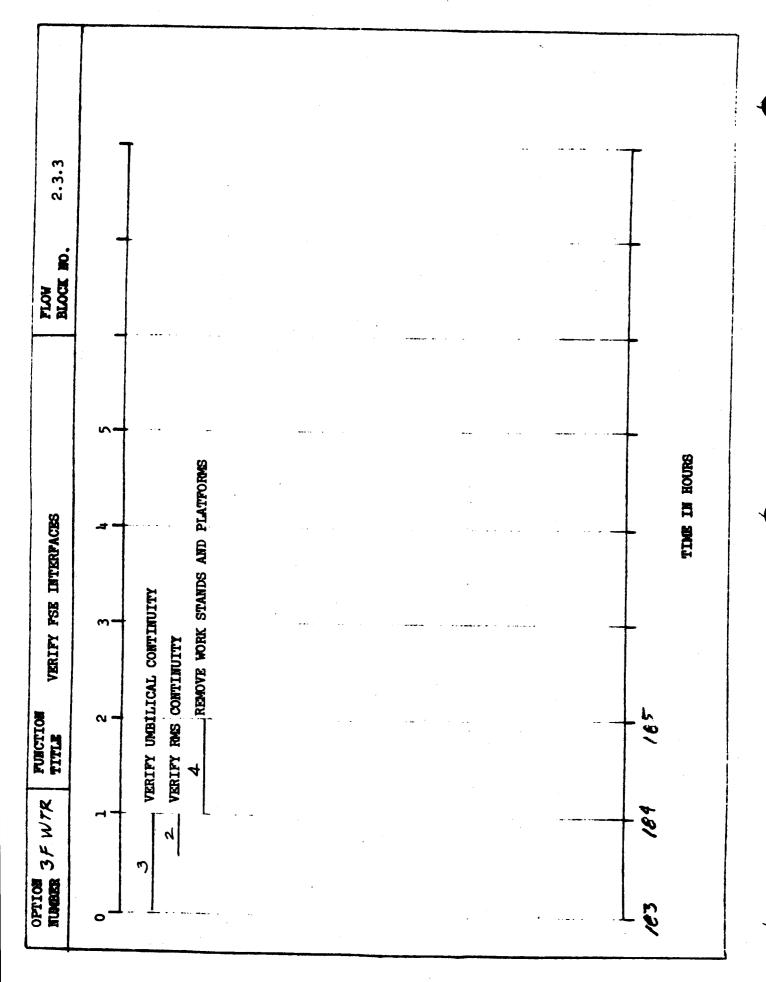
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2.3.1	7										·		••	•• ·•			
FLOW BLOCK NO.	6	·								 		D MISSIONS					
	5				IN MCF AT ORBITER AREA	PAYLOAD BAY CLEAN COVER	DING PSE	UNITOAD PSE			 	*HOTE: ADD FOR DOD MISSIONS				153	TIME IN HOURS
RESTONCE	e -				• •	Δ.	S FOR UNILOADING FSE	9		· no staph with						152 15	H
TRANSFER	• •	CORT	EA	O MCF	POSITION TRANSPORT	SET UP	3 PREPS								ww 188		
TITLE	~ -	SECTIBITITY ESCORTI*	TRANSPORT CLEAR AREA	TRANSPORT TO MCF	2 POSITI	4	•				•		•			57	
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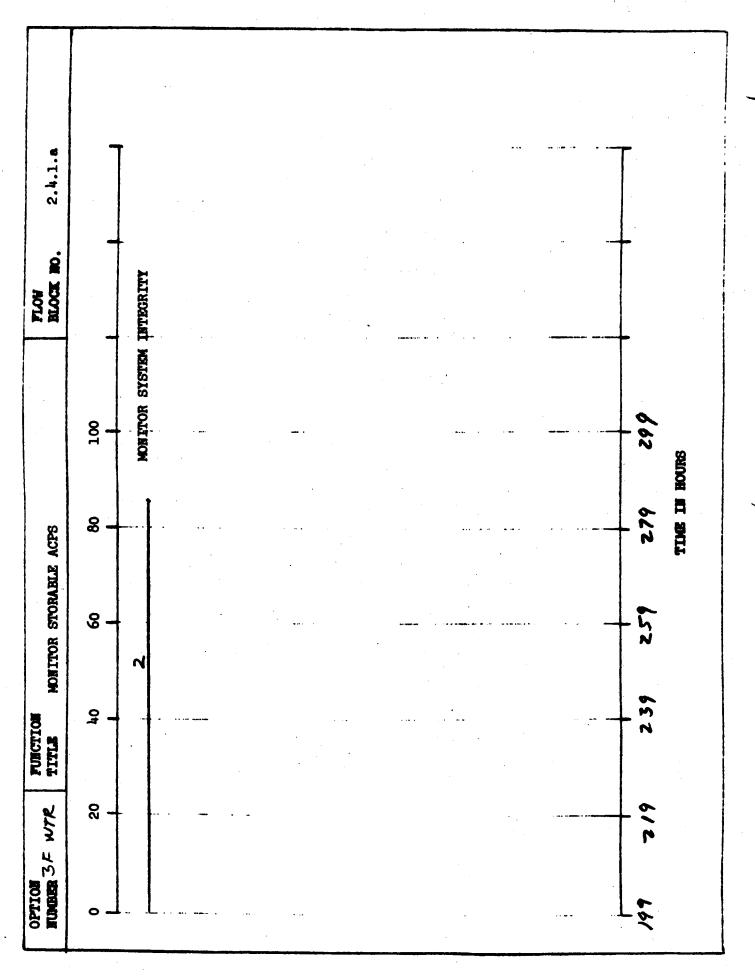




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BLOCK NO.		-											8,4		8			. ·		
		COVER		Let						TUG	ULTY	*	MECHANICAL I	M #5	HYS./MECH. I/	AD BAY DOORS	TENT			
N MCF	<b></b>	AIR FLOW IN COVER					TION #3	TO TUG	LOX DUMP INTERPACE	MATE FLIGHT UMBILICALS TO TUG	VERIFY INTERPACE CONTINUITY	LOWER TO POSITION #4	MATE AFT PHYSICAL/MECHANICAL IT'S	LOWER TO POSITION #5	S MATE FORWARD PHYS. /MECH. I/F's	CLOSE PAYLOAD BAY DOORS	A REMOVE TENT		 161	TIME IN HOURS
PAYLOAD INSTALLATION MCF	9_				SITION #1	TION #2	LOWER AFT SLING TO POSITION	SE UNBILICALS TO TUG	MATE LOX DUMP	MATE FLIGHT	4 VERIFY I		S MAT	10					 189	
TITLE PAYLO	વ _	/		TRANSPORTER RELEASE	2 HOIST PAYLOAD TO POSITION	LOWER TO POSITION		* NATE GSE UN	4	4	·				•				 187	
NUMBER 3F W/R T	2 _		POSITION CRANES	4 TRANSPOR	2 HOIST	4	d											•••••••••••••••••••••••••••••••••••••••	 185	
DORER	0 -		4																12	



	11	PURCETOR	VERIFY PA	YLOAD-TO-E	PAYLOAD-TO-SHUFFLE INTERFACES	CIES	PLOW BLOCK NO.	2.3.9	
0	· ~ ~	=			8 10		12 L		
9	15 to	3 380	SET UP GSE; COMBET CAN	HERS, COMM	CONTRCT UNBILLICALS				
1 1 1 1 T SA SAD	<u>)</u>	NOVER 1	r/Pores	SOFTWARE				•• •	
	•	-	-	ALIDATE (FL	(FUNCTION TEST) ORBITER FLIGHT INTERFACES WALLDAME HIG SOFFWARE IN ORBITER	RBITER FLIG	RT INTERPACES ORBITHER		
	n	1	0		PRESSURE AND LEAK TEST OF Q/D'S	LEAK TEST O	r q/b's	. •	
				<b>F</b>	10 RESCHEICAL SHUTDOWN 10 DISCORNECT GS	SHUTDOWN ORR,	LICAL SHUTDOWN DISCONNECT GSE, UMBILICALS, CABLES	ABLES	
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18/	1/3	195	~	-6	561	·	•	•	
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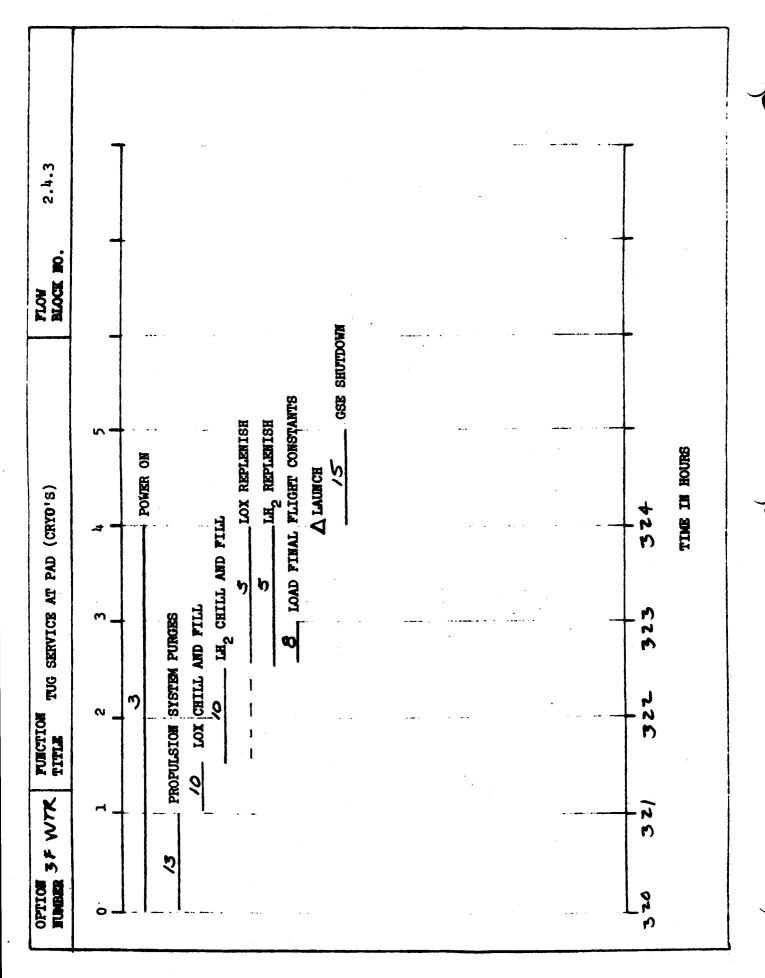


ELECTRICAL UNBILITICAL BYOKUP FLUID UNBILITICAL BYOKUP  FLUID UNBILITICAL BYOKUP  A VALIDATION TESTS  97 292 7:73 TIME IN BOURS	MOCK NO.	-								 en vege en	-	
LIDATION LIDATION CKUP		-		·								HOURS
ECTRICAL UMBILLICAL JUID UMBILLICAL HOOK    2 2  2 2  2 2  2 2  2 2  2 3  2 4  2 5  2 5  2 6  2 7  2 7  2 7  2 7  2 7  2 7  2 7	٦ I	e -	HOKUP		IDATION						- 22	TIME IN
	TITLE TOU SERVE	∾ _	ECTRICAL UMBILICAL	UID UMBILICAL HOOK	0			- <del></del> -	• • • • • • • • • • • • • • • • • • •		 _	

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2.4.1											•				
FLOW BLOCK NO.	12							manage 1					منان بعد العاد	-	
SYSTEM TEST	10 1		POWER ON	ဖ	UE SIMULATED FLIGHT TEST	POWER DOWN			<u>.</u>				<u>-</u>	<del> </del>	936
ORBITER/PAYLOAD INTEGRATION SYSTEM TEST	æ <del></del>			PRESSURE TEST Q/D'S	SOFTWARE SIMULAT	7						. •		30/	TIME IN HOURS
RBITER/PAYLOA	9 -	L HOOKUP QUID HOOKUP	ල ස	PRESS	LOAD FINAL SOFTWARE	<b></b> .				• •	·•••••••••••••••••••••••••••••••••••••			662	
FUNCTION O	.a =	GROUND ELECTRICAL HOOKUP PNEUMATIC AND LIQUID HOOKUP	10 POWER TEST	9	6			Marin I						162	
OPTION 34 WIR	α_	/O GROI	2/	<u>.</u>							-	<del>-</del> -		295	
OPTION	o <b>-</b> -	L.			· .							•• ·		722	

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OPTION 3F WIR	TITLE	- 1	TUG SERVICE AT PAD (CRYO'S)*	(CRYO'S)*		FLOW BLOCK NO.	2.4.3.8	
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		,	0/	ACTIVATE FUEL CELLS	t cells	- -		
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*POR PURT. CRITES	pe		TI	TIME IN HOURS				



SUBSYSTEM HOHITORING AT PAD BLOCK NO. 2.4.4	12 16 20	7 MONITOR LAUNCH REDLINES					314 318 327
 FUNCTION SU TITLE	ω -			e de la companya de l	· •••	<u> </u>	

## TASK TIMELINES

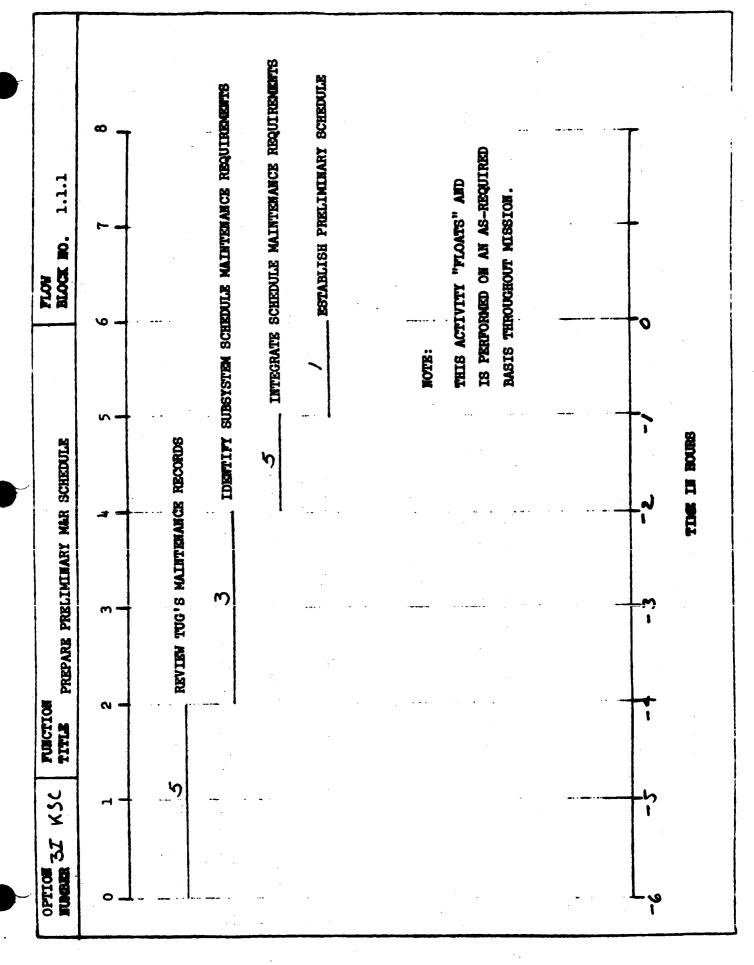
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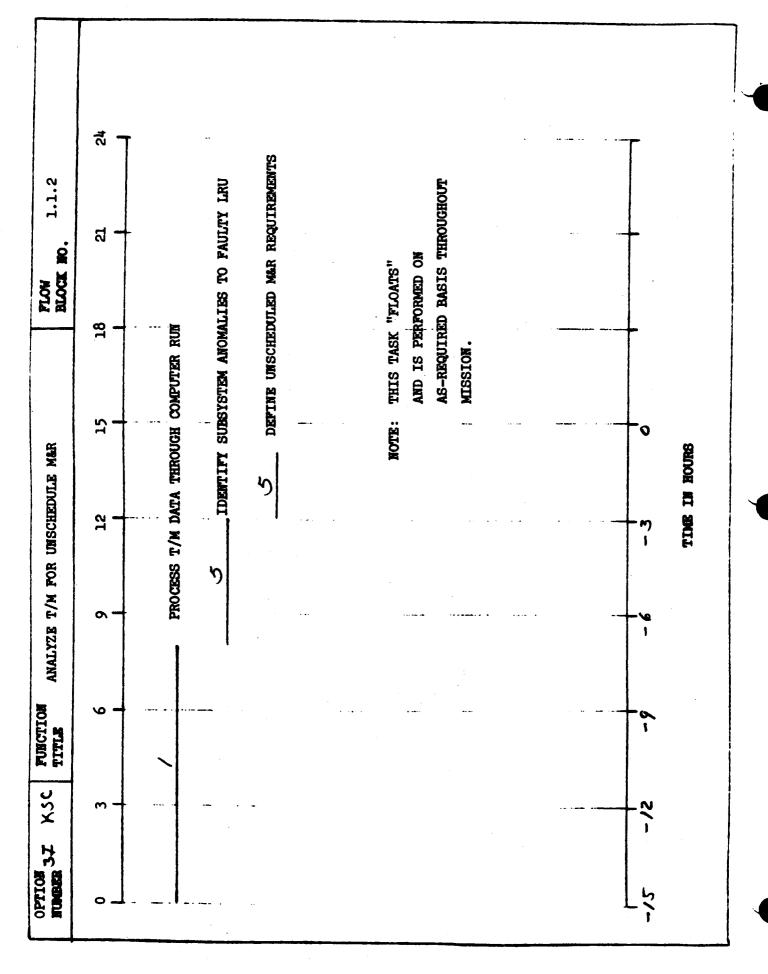
THE CRYOGENIC TUG

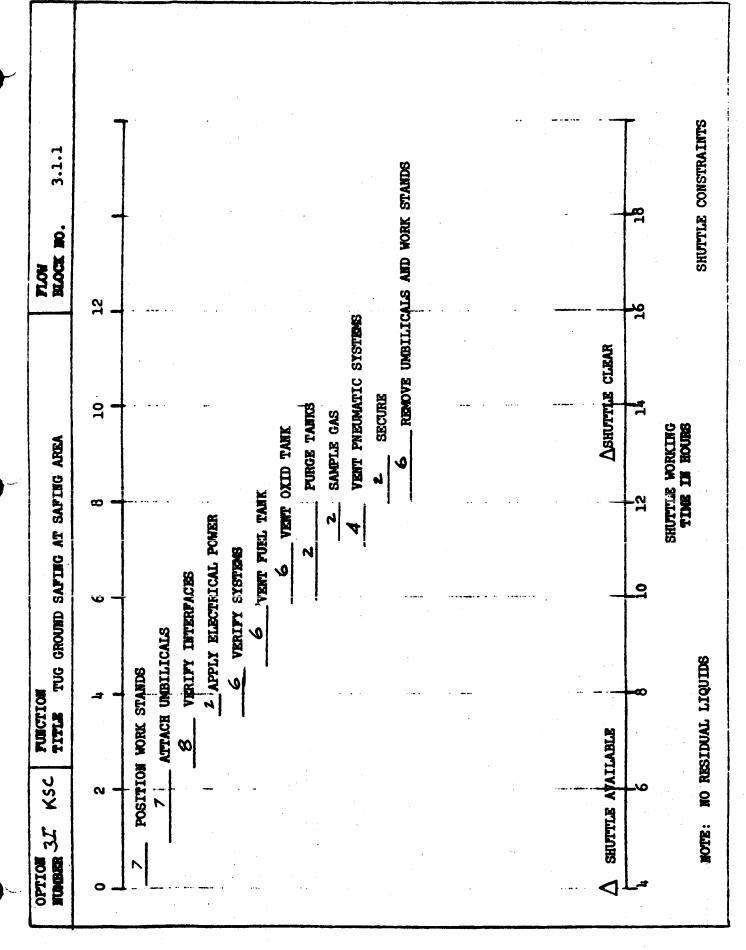
GROUND AND LAUNCH OPERATIONS

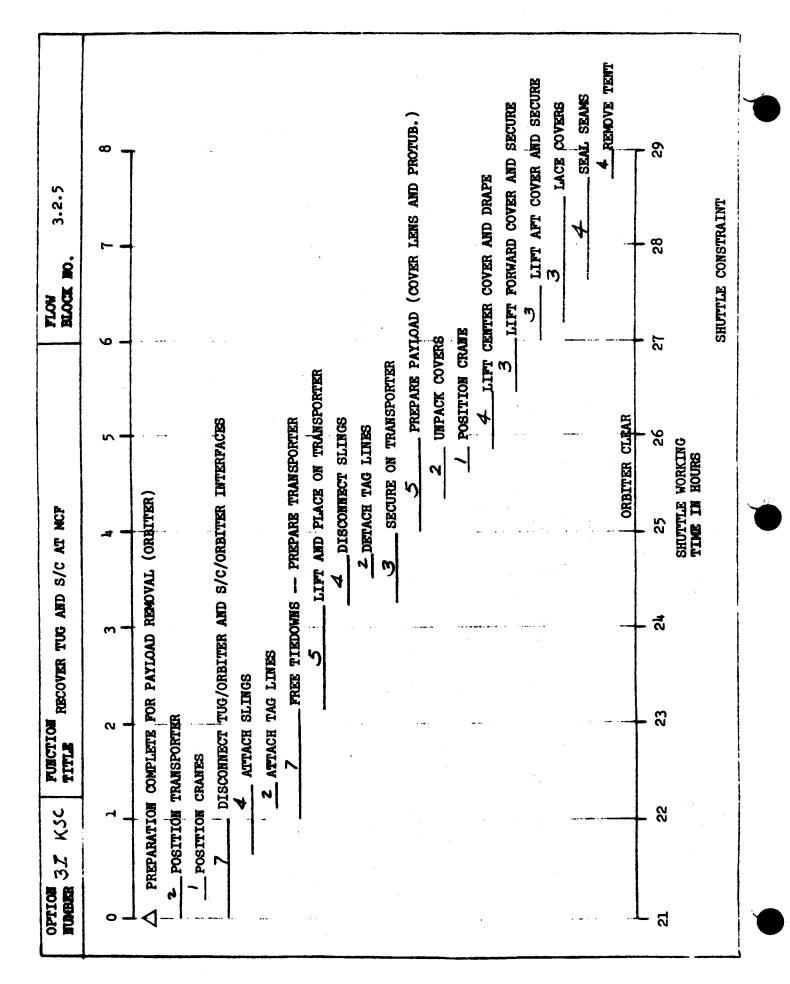
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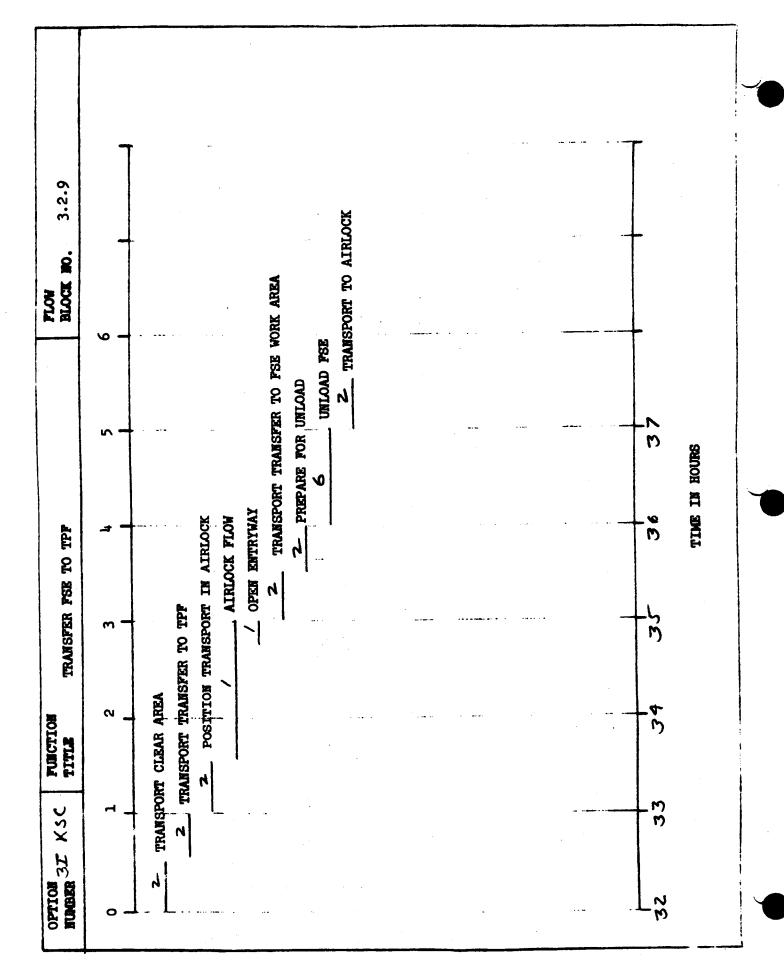




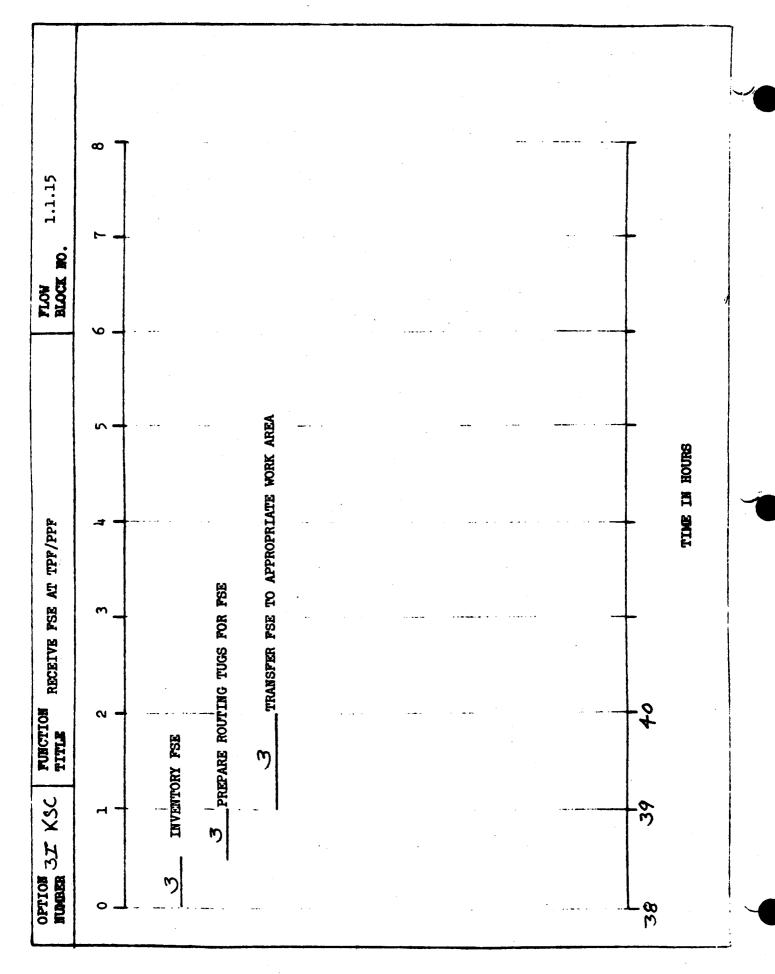




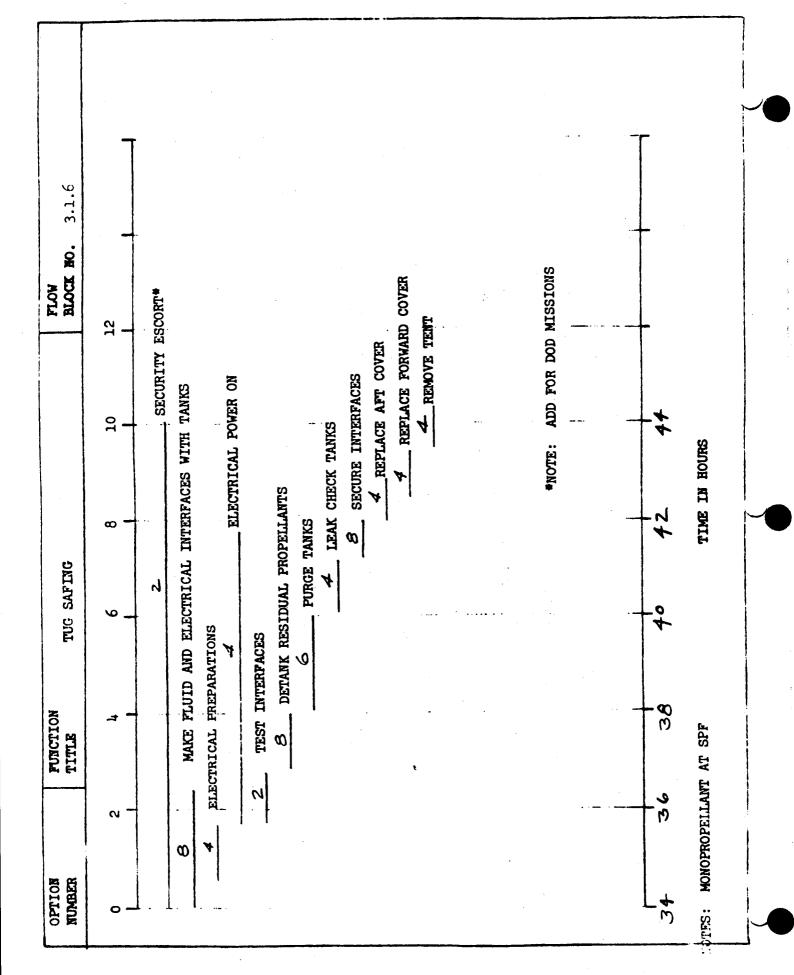
3.2.7	_		. <u>.:</u>			RT		NDS			· · · · · · · · · · · · · · · · · · ·	apr 1440 - 150	· ·		
FLOW BLOCK BO.	7	·	: <u>.</u>	Ħ		. RECEIVE AND STOW FSE IN TRANSPORT	FSE	REMOVE WORKSTANDS						30	
PSE (PAYLOAD BAY) EQUIPMENT	5		OVE GSE AND FLIGHT UNBILICALS	REMOVE LOX DUMP INTERPACE	FIENDVE RMS END EFFECTORS		SECURE PSE	4						62	TIME IN HOURS
	m —	DS AND PLATFORMS TON PER TRANSPORT	-	2 2	72 FIEDOVE	*	-		/ But serings has					22 28	100
FUNCTION RECOVER	~ ~ ~	POSITION WORKSTANDS A	19						···• .	. <b>.</b>				-%	
NUMBER ALL	0	*			•									24 25	



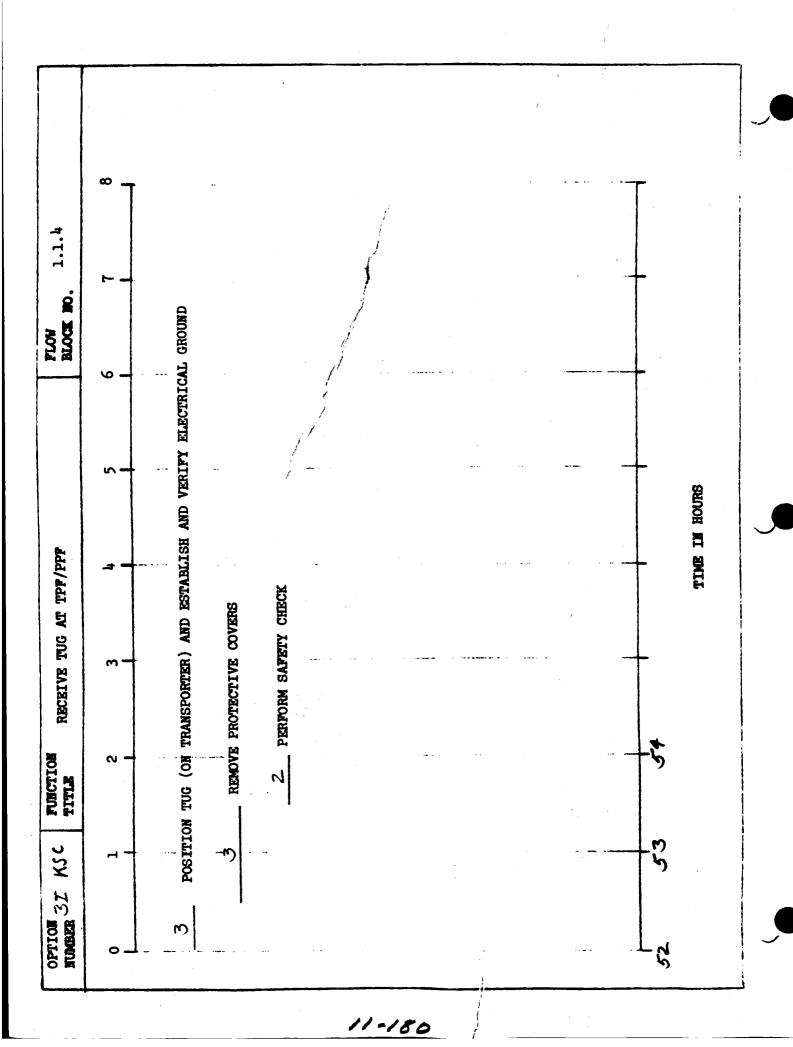
		<b>3118</b>			
1.1.3	8	D MAR REQUIREMENTS			
BLOCK NO.	•	INTEGRATE SCHEDULED AND UNSCHEDULED MAR REQUIREMENTS  / UPDATE MAR SCHEDULE	·		6
	<b>N</b> -	GRATE SCHEDULE	<del>-</del>		39 HOURS
SCHEDULE	_	INTE			TIME IN HOURS
UPDATE MAR SCHI	m <del> </del>		··		m v
TITLE	2	Ŋ		. <u>.</u>	. 9 9
3T KSc	-				, p
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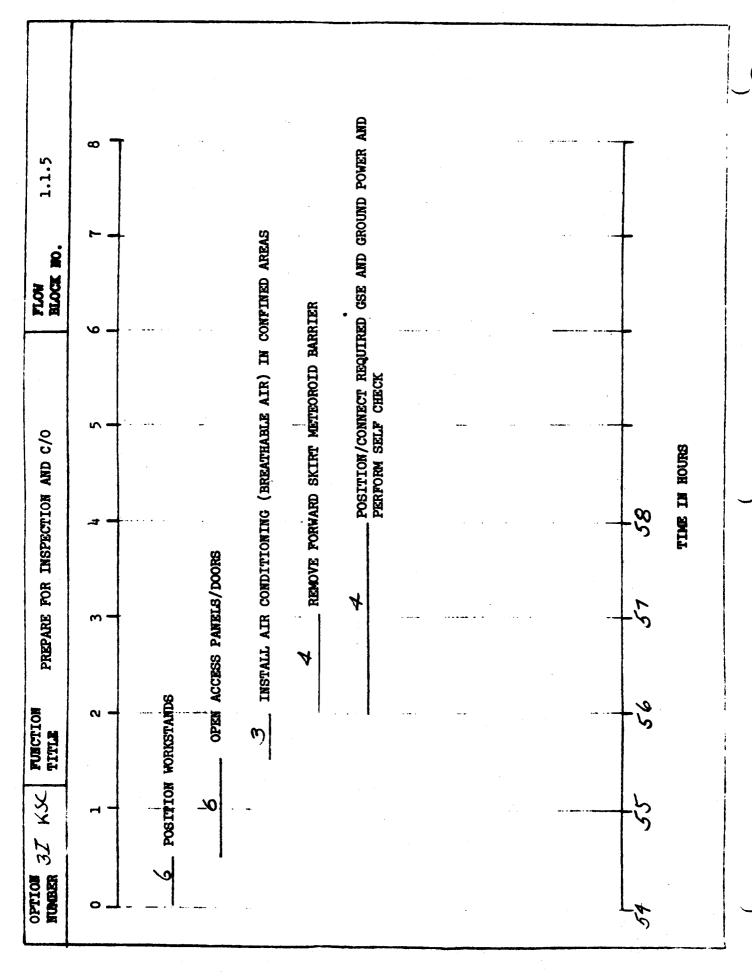
3.1.4	<b>-</b>	•							TE PURGE								- w			
FLOW BLOCK NO.	9 -	SECURITY ESCORT®	•••	•					INITIATE CELLING TO FLOOR FLOW/TERMINATE PURGE		REMOVE FORWARD COVER	. France	• .			FOR DOD MISSIONS			-	
id	~ <del>-</del>	SECUR		***				LE TENT	CEILING TO FLO	OVE APT COVER	1				•	*NOTE: ADD FOR	·	- · • <del> •</del>	34	I HOURS
TUG AND S/C TO SPF			/F WITH COVER		AREA		SPORTHR	POSITION PORTABLE TENT	2 INITIALIE	3 REMOVE				\					33	TIME IN HOURS
TRAISFER	m	2			R AND CLEAR	TRANSFER TO SPF	POSITION TRANSPORTIN	A	_ 1							***			32	
KSc FIFE	1 2		MAKE POSITIVE PRESSURE PURGE I	INITIATE PURGE	ATTACH TRAC	TRAN	7												30 3	
OPTION 3Z K	0 -		2 MAKE	4	4				•								. <del>.</del> .		67	-



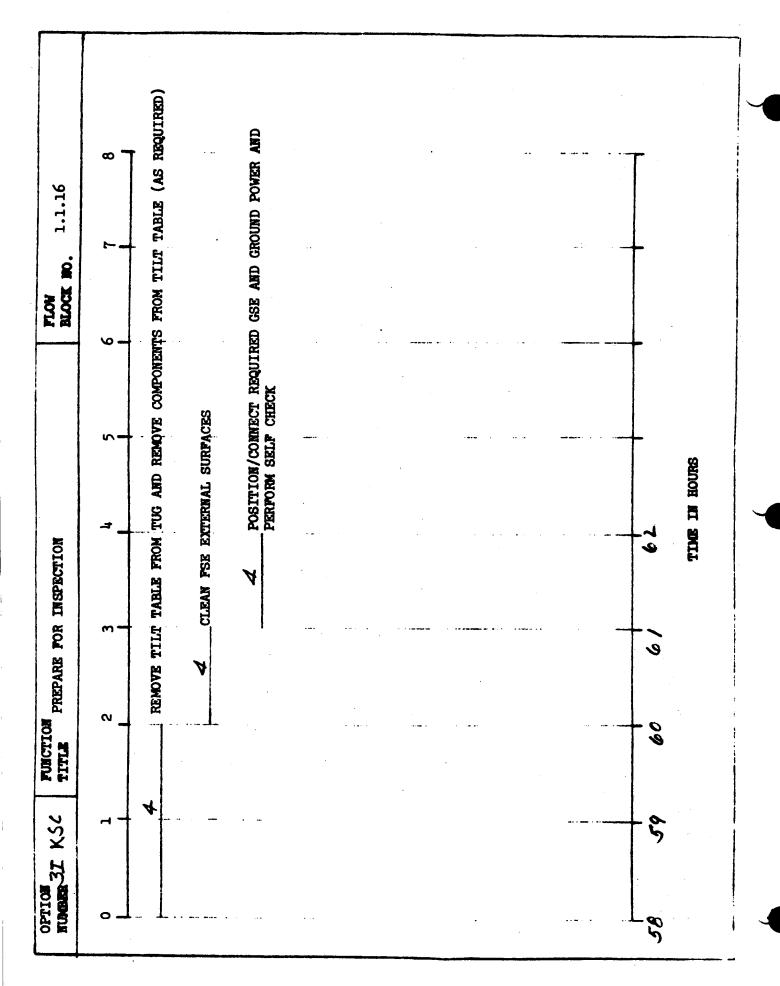
												VEION							
3.3.6	_									>		TRANSFER TO WORK STATION				 ÷			
FLOW RLOCK NO.	9		<b></b>							AIRLOCK FLOW	A	TRANS	<b>-</b>		ADD FOR DOD MISSIONS			16	
T TO TPF	<b>∽</b>	-	<b>.</b>					- <b></b> -	HEMOVE COVERS		·			·	*HOTE: ADD FOR D			50	IOURS
TUG AND SPACECRAFT TO	4=	· Li				OF COVER	SOVERS	I CRANTE	İ	,								46	TIME IN HOURS
TRANSFER TU	<sub>6</sub> η =	SECURITY ESCORT®	CLEAR AREA	ļ	ER TO 'TPF PLACE IN ATRIOCK	TERMINATE PUNCE OF COVER	d UNLACE COVERS	2 POSTITION CRAME	מ								_	7 48	
FUNCTION	o -		ATTACH TRACTOR AND	INITIATE PURGE	Z PLACK IN	1			. •			: <b>-</b>						+	·
B37 XSC	<b>~</b> ~	7	2 ATTACH 1	7 HIT	1					,								46	
OPTION 3.7	o -	1_	_	··				•								 		7 \$	



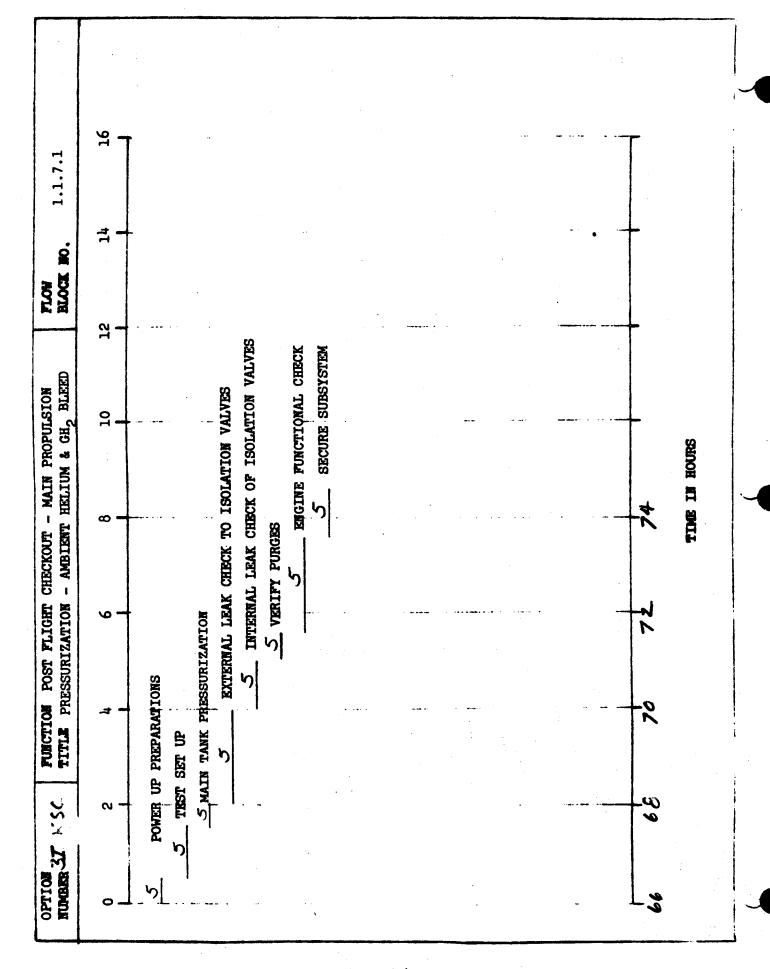
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PLOW MLOCK NO.	6						. Production in	· was seed	• 4			
	5				<b></b>		T BQUIPMENT	<b></b>			<u></u>	
AND SPACECRAFT	4 -				D TGG	ACECRAFT	REMOVE SPACECRAFT EQUIPMENT				28	TIME IN HOURS
DEMATE TUG AND SPA	<b>м</b> –		CING(8)		DEMATE SPACIECRAFT AND TOG	TRUNSFER SPACECRAFT	2 18	· · · · · · · · · · · · · · · · · · ·		_	95	
FUNCTION DEMAN	∾ -	D WORKSTAND	ATTACH SPACECRAFT SLING(8)	H CRAFE		<b>"</b>	• • • • • • • • • • • • • • • • • • •				52	
KSc	д-	POSITION END WORKSTAND	3 ATTACH	POSITION CRANE	*						35	
OPTION 3Z RUBBER 3Z	<b>0</b> –	m									75	



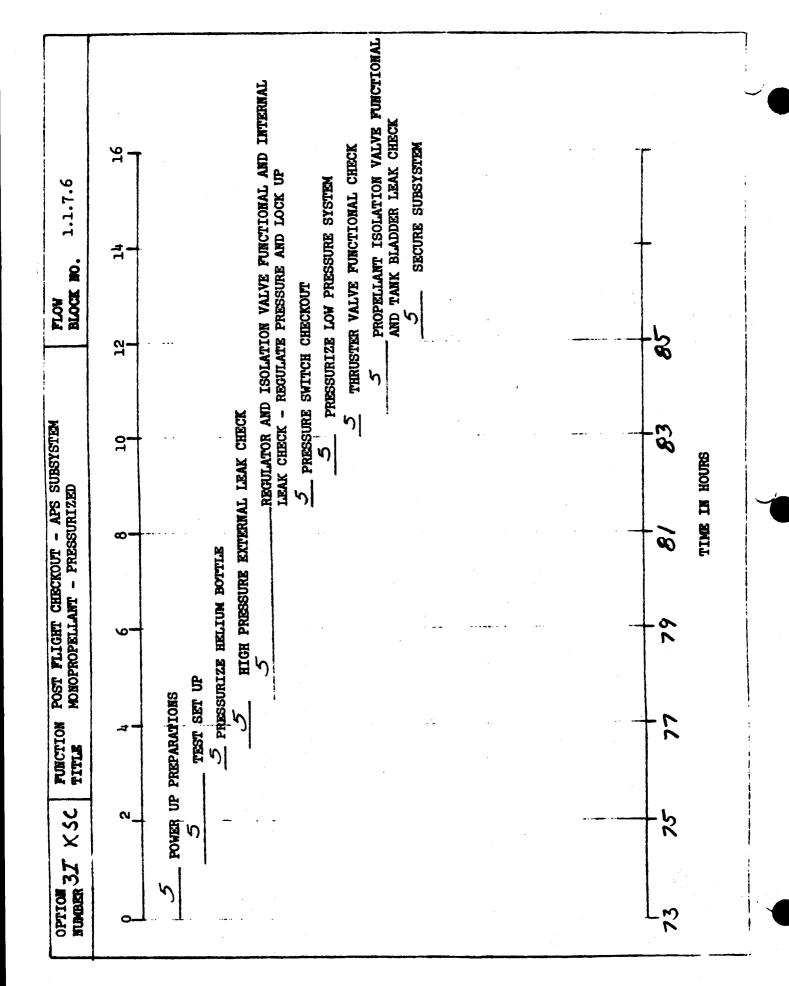
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1.1.6	14	SYSTEM								_	
PLOW BLOCK NO.	12	INSPECT STRUCTURES/MECHANICAL SUBSYSTEM	BSYSTEM	SYSTEM	SCREPANCIES			 •		-	
INSPECTION	97	TRUCTURES/ME	INSPECT PROPULSION SUBSYSTEM	INSPECT AVIONICS SUBSYSTEM	SUBSYSTEM DISCREPANCIES			 o and -		_	
PERPORM POST PLIGHT RECEIVING INSPECTION	8	INSPECT ST	INSPECT P	INSPECT	DOCUMENT	·				99	TIME IN HOURS
POST FLIGHT	9 _			<b>S</b>						69	Ħ
PERFORM		4		3	- 2						
FUNCTION	<b>⊅</b> =	🔨	4			•			, yak danad	79	
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OPTION 3I	0 -					CONTRACTOR OF THE STREET				85	

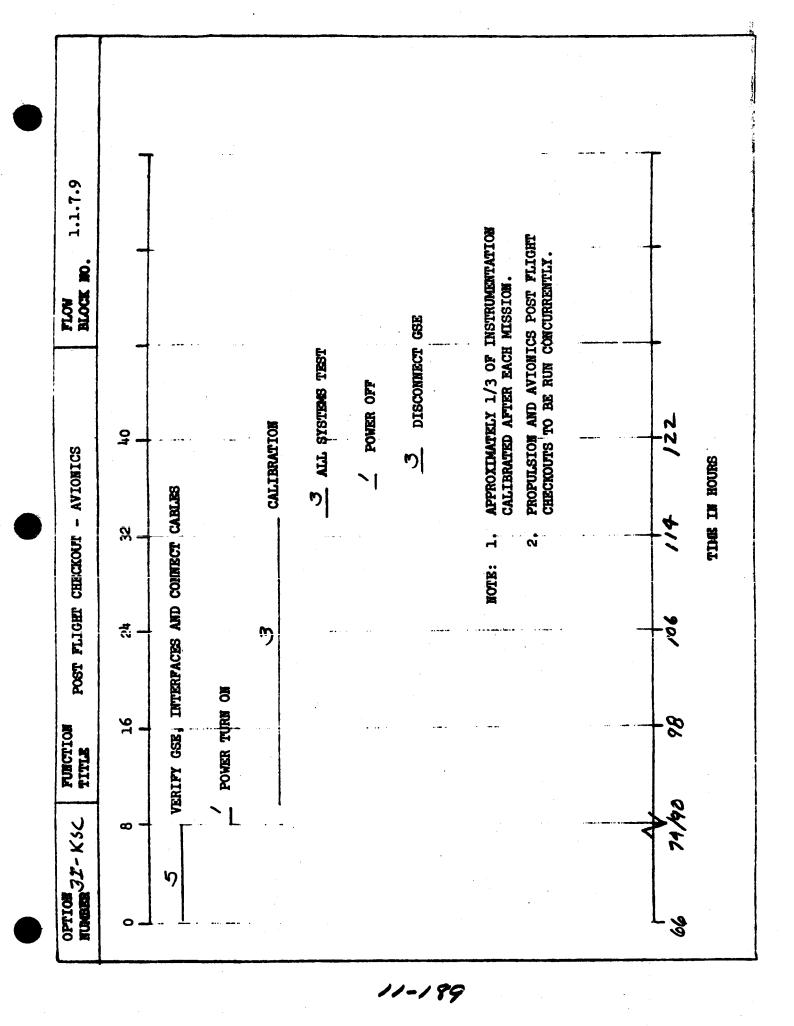


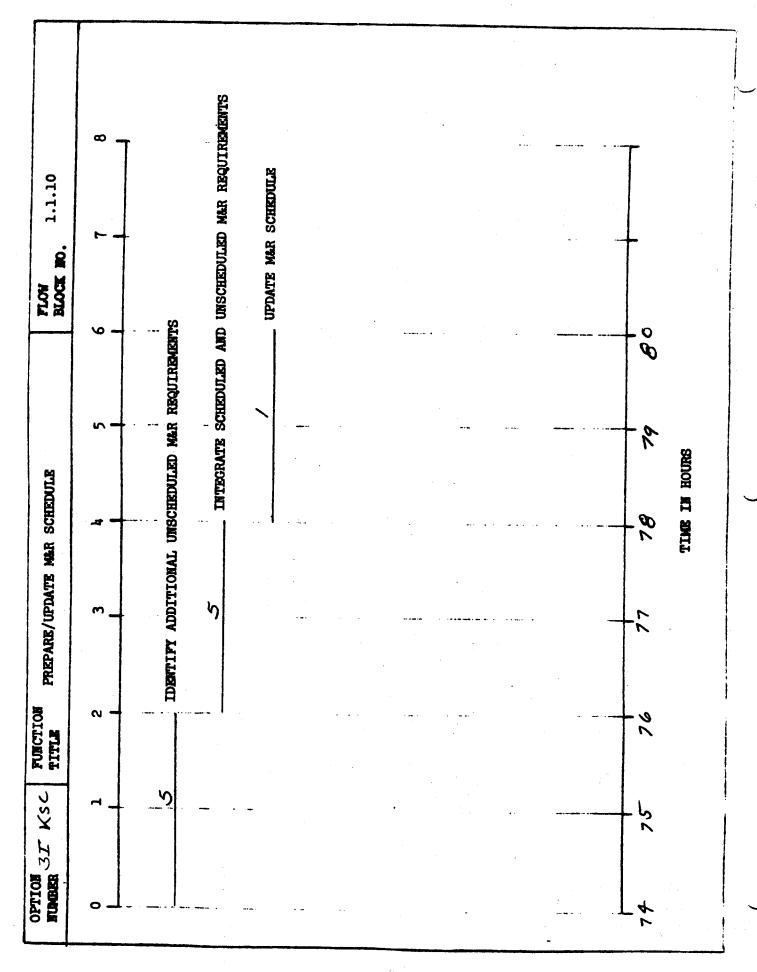
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	88		And Warsing interpace equipment: support equipment	INSPECT FLUID UMBILICALS INSPECT ELECTRICAL UMBILICALS	DOCUMENT P					·	*	
	9		m	2 INSPR	"			 	• • • • • • • • • • • • • • • • • • •		72	
7777	-3 -	INSPECT TILT TABLE 2 TRESPOND	Z INSPECT RM		7			 ·			, r	
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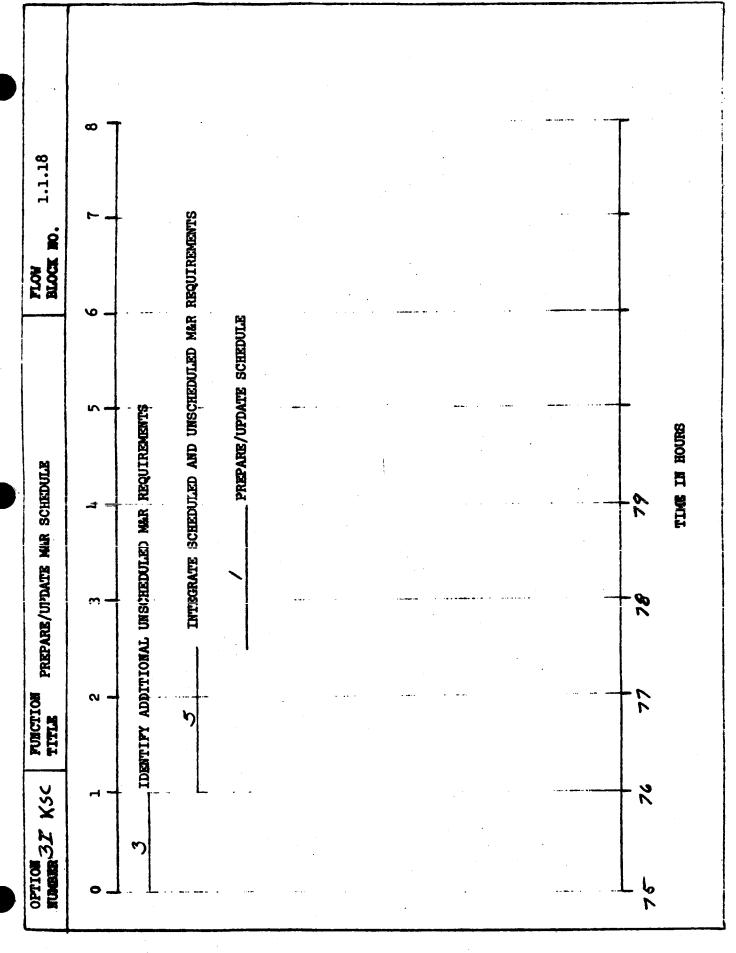


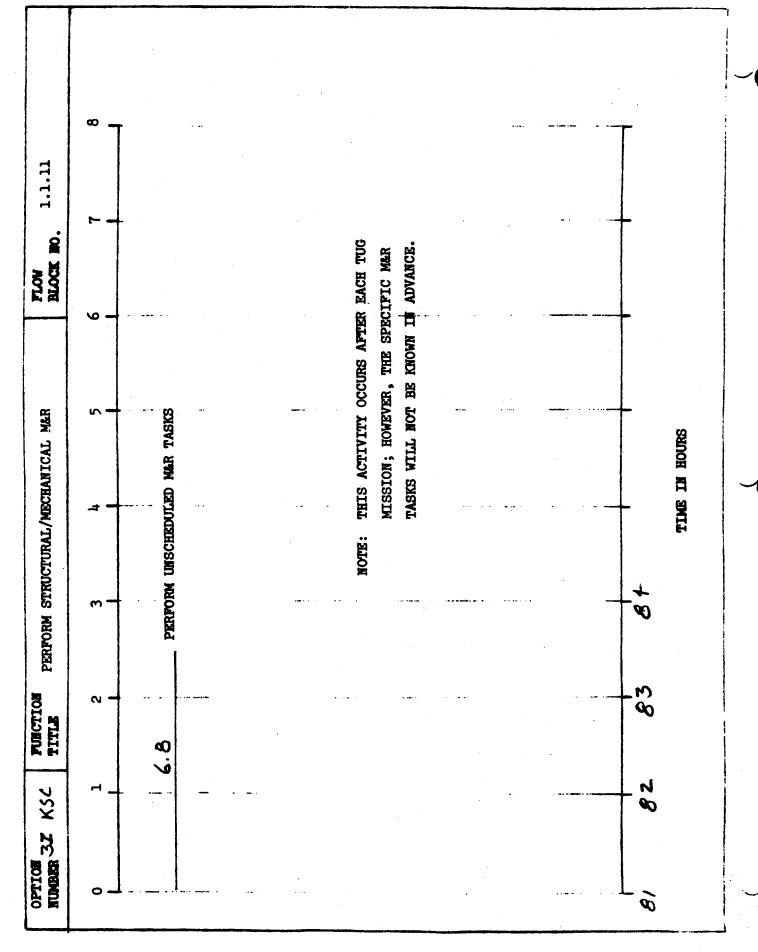
MOHOPROPELLANT - ELOWDOWN BLOCK NO. 1.1.7.5	6 8 10 12 14 16 1 1 1 1 1		PRESSURIZE MANES AND FEED SYSTEM	THRUSTER VALVE FUNCTIONAL CHECK	SECURE SUBSYSTEM				72 74	THE HOUSE
HUBBER 37 KSC TITLE HONOPER	4 2 4	5 POWER UP PREPARATIONS	STEST SET UP	DHET D			•	 •••	06 68 70	

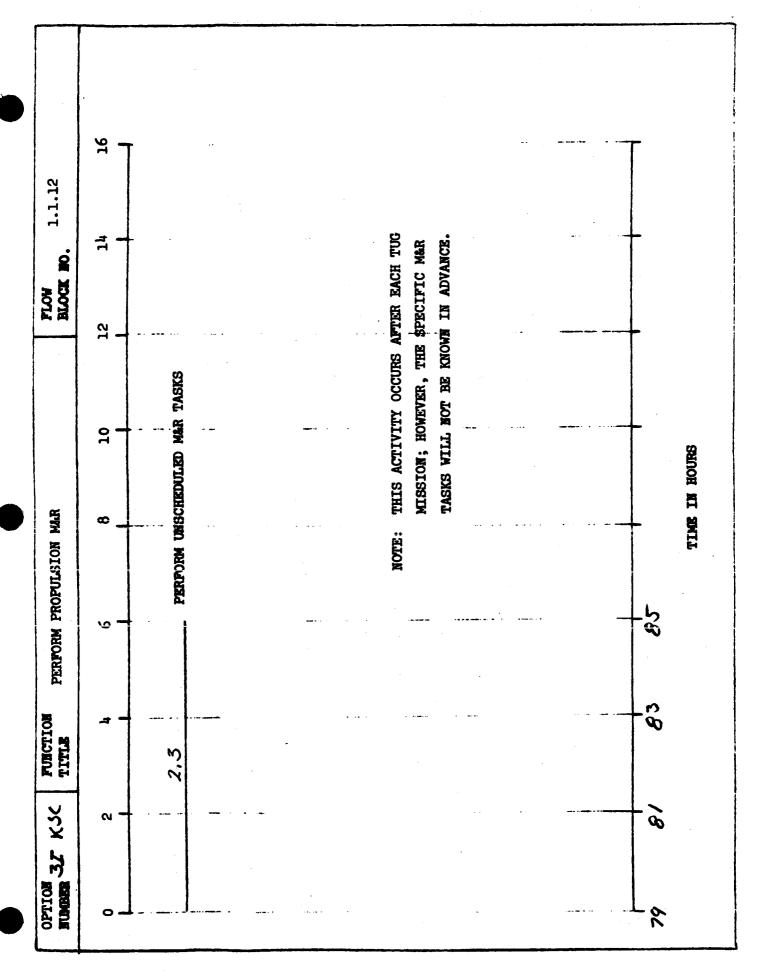


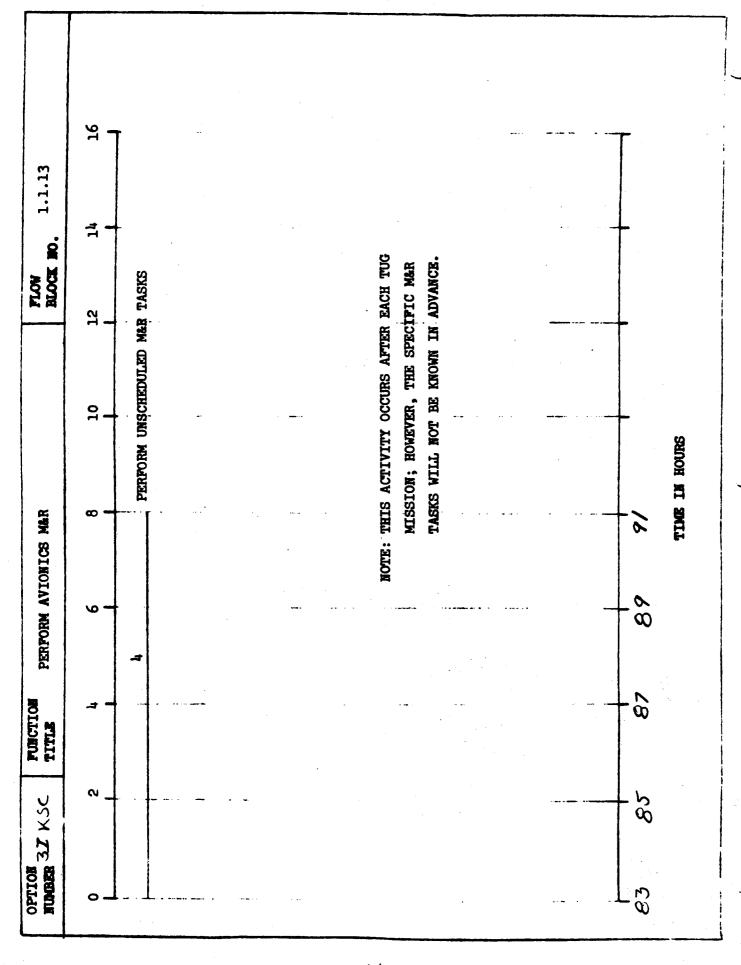








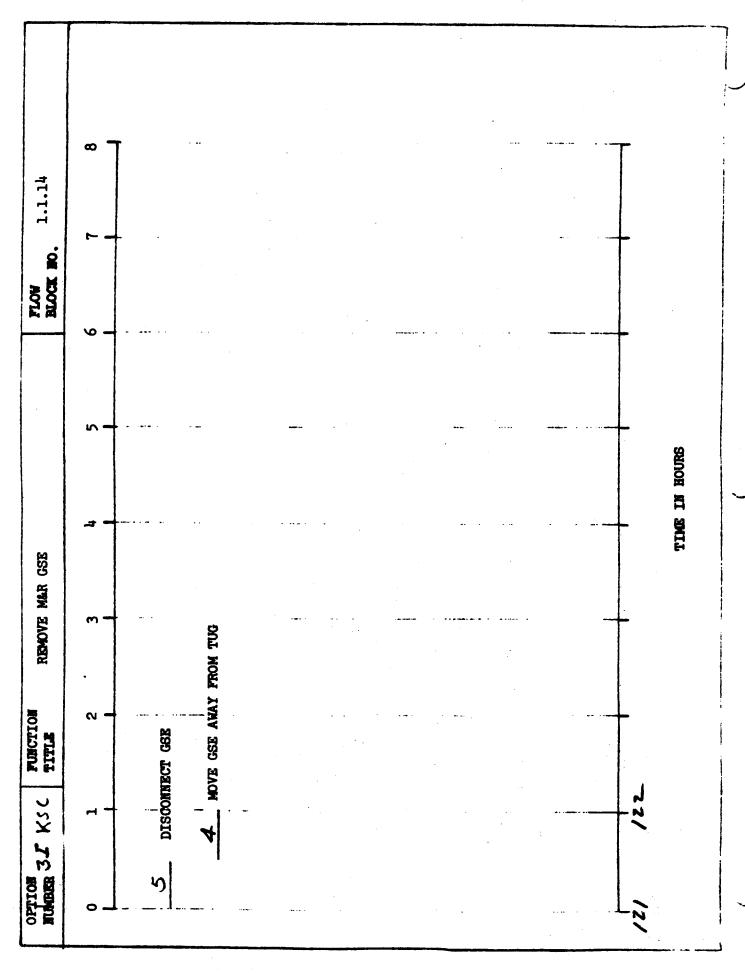




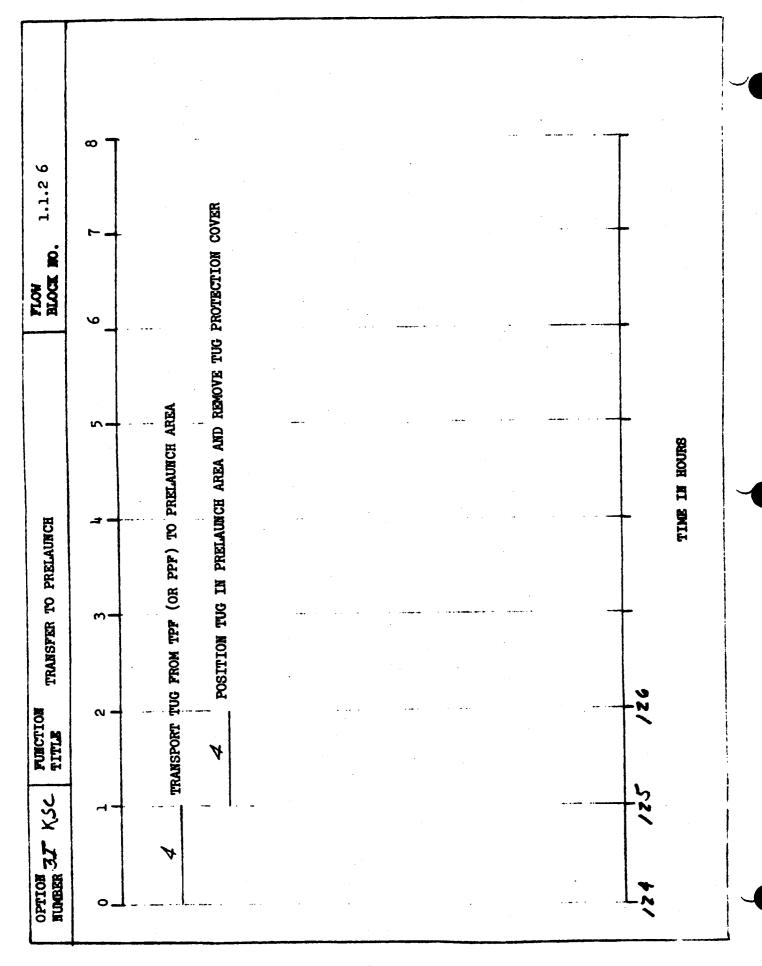
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BLOCK	77 1	STRUCTUR	AVIONICS	PROPULSI	TUID UMBI		AFTER EACH	ATED SKILL	-		-	
	16 20	PERFORM UNSCHEDULED STRUCTURAL/MECHANICAL MAR	PERFORM UNSCHEDULED AVIONICS MAR	PERFORM UNSCHEDULED PROPULSION MAR	CLEAN AND PACKAGE FLUID UMBILICALS		THIS ACTIVITY OCCURS AFTER EACH TUG MISSION; HOWEVER, THE MAGNITHIDE OF INDIVIDUAL SUBSYSTEM UNSCHEDULED	MAR TOGETHER WITH RELATED SKILL REQUIREMENTS WILL VARY.			66	TIME IN HOURS
FSE M&R	12					. ·	NOTE:	i de la compansión de l			- 56 - 56	. 5'
TITLE PERFORM FSE	8 -			,	/			. <del>.</del> .		<del></del> .	16	
KSC			-								69	
NUMBER 32				******							[ &	

2 PERFORM STRUCTURES POST MAR VERIFICATION  2 PERFORM AVIONICS POST MAR VERIFICATION  2 PERFORM AVIONICS POST MAR VERIFICATION  40 99	NUMBER 37 K	KSC TIT	TITLE	POST MAR VERIFICATION	I FICATION		BLOCK NO.	1.2.1	
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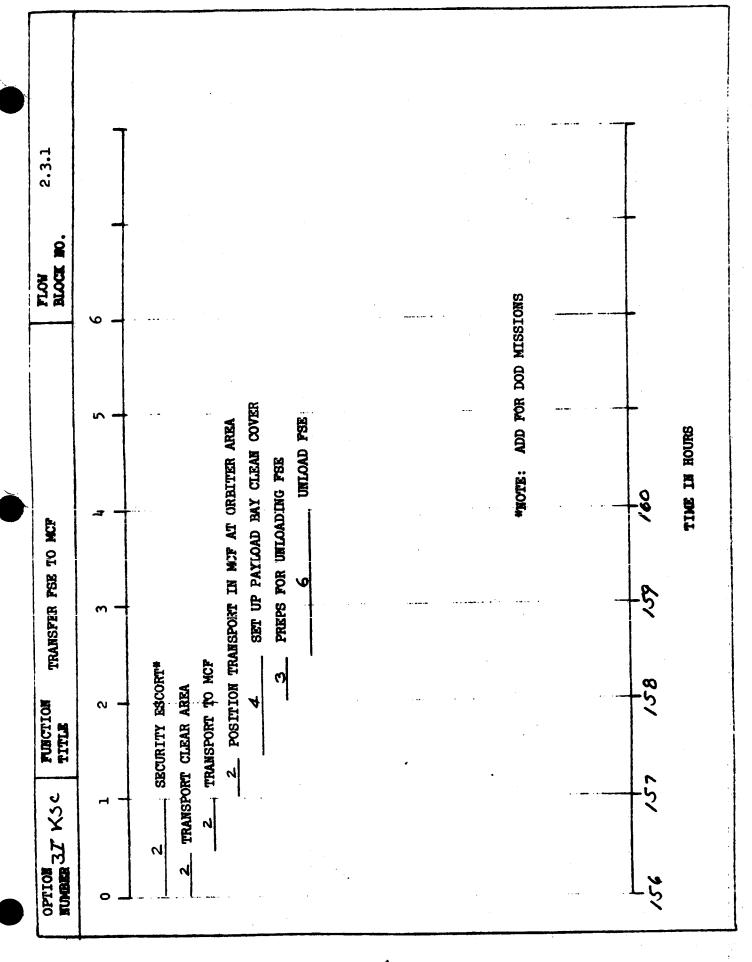


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	5	• • •••	 -	AND HOOK UP TO PRIME MOVER			•					•	TIME IN HOURS
PREPARE FOR TRAINSPORT	.a —	PANKIS	TIVE COVER	D ROOK UP TO	. •				• • •			•	TIME
PREPARE FOR	m <del>-</del>		INSTALL TUG PRCTECTIVE COVER	CLEAR AREA AN	• • •		·		•	,	+		
TITIE	2	CLOSE AND SECURE ACCESS	4 INSTAL	4			· • ·	Men de la companya de		•		42/	
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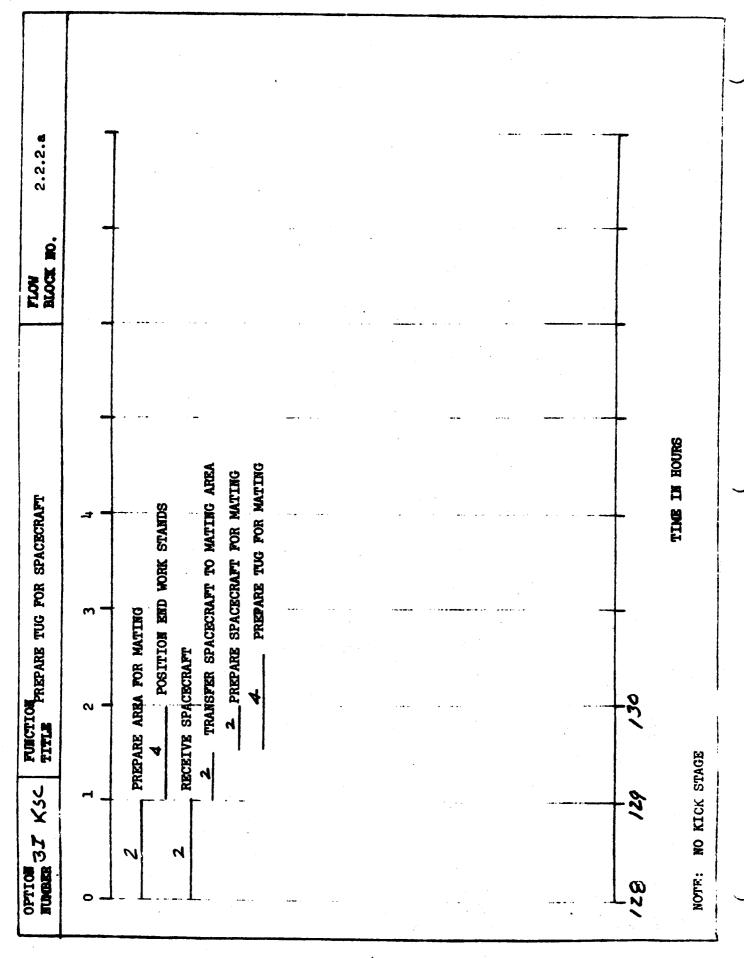
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BLOCK NO.	9	. <b></b>				ION	RT	ACE	TO TRANSPORT	COMSEC AND CONSOLE LOAD COMSEC AND CONSOLE	SECURE TRANSPORT			-		-	
	w —			POSTTION	ANSPORT	TRAMSFER SERVICE PANEL TO WORK POSITION	LOAD SERVICE PANEL INTO TRANSPORT	TRANSFER LOX DUMP INTERFACE	LOAD LOX DUMP I/F INTO TRANSPORT	4 TRANSFER COMSEC AND CONSOLE 4 LOAD COMSEC AND CON	4			<b></b> -	· · · · · · · · · · · · · · · · · · ·	145	OURS
PSE PROM MER	<b>⇒</b>	• • • • • • • • • • • • • • • • • • •	SITION	D TRANSPORT MARTITCALS TO WORK POSITION	UMBILICALS INTO TRANSPORT	RVICE PANEL	ERVICE PANEL	TRANSFER LO	2 LOAD LO	4 1	•		, .			#	TIME IN HOURS
RECRIVE PSE FR	e	RANSPORT	S TO WORK POSITION	S INTO TRANS	LIGHT UMBILI	TRANSFER SE	2 IOAD 8	4	•			. ,,	·		~~~	143	
TITLE RE	- 5	PREPARE AREA AND GSE TRANSPORT	TRANSFER GSE UMBILICALS TO	LOAD GSE UMBILICALS INTO TRANSPORT  2	J LOAD FLIGHT	4									•••	241	
KSC	ч-	PREPARE AF	₹	3 LOAD 0		-			•					a <del></del>	- · • · <del>• · • · • · • · • · • · • · • · </del>	141	
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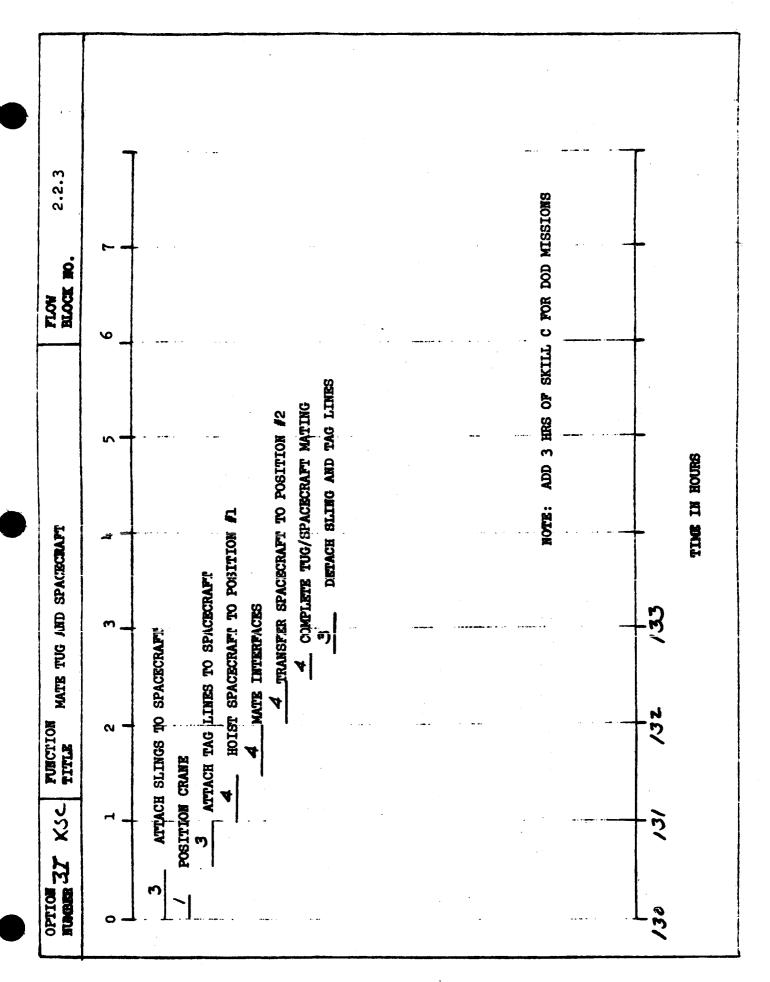
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	<b>L</b>	· • • • •	- <del>-</del>			 ••• ·	<del>.</del>		TIME IN HOURS	
TUG FROM M&R	ε				RK STANDS	· .			FID	
RECEIVE	2-		TRANSFER TUG TO WORK STATION	POSITION TRANSPORTER	INSTALL SIDE WORK STANDS				87	
FUNCTION TITLE	н_	PREPARE AREA	SFER TUG TO	POSITION 1	4			e e	127	
OPTION 3 L KSC	٥_	2 PRE	2 TRA	<b>m</b>					 7 92.	



2.3.2.2	-							. · · · · · · · · · · · · · · · · · · ·	··· ··· ··			
FLOW BLOCK NO.	9	TW COVER			UMBILICALS PORT HARDWARE	INSTALL LOX DUMP I/F						
	٧ –	AIR FLOW IN COVER		RIFY	INSTALL FLIGHT UMBILICALS INSTALL TUG SUPPORT HARDWARE	2 INSTALL 2 INSTALL		 		165	HOURS	
IN PAYLOAD BAY	.a		PLATFORMS	CE PANEL AND VERIFY THSTAIL, CSF HWRITICALS	4			 - ·- ·		+9/	TIME IN HOURS	
73.	m <del>-</del>	M COVER		INSTALL SERVICE PANEL AND VERIFY			CPS SMB AB	••••••••••••••••••••••••••••••••••••••		163		
FUNCTION INSTALL	<b>2</b> -	POSITION CLEANROOM COVER	POSITION WORK STANDS AND  3 REMOVE BLANK PANEL	THSTA			·-· .			79/		
KSK	1	POSIT	POSITI							191		
OPTION 3L	0 _	<b>v</b> )	*							/60		

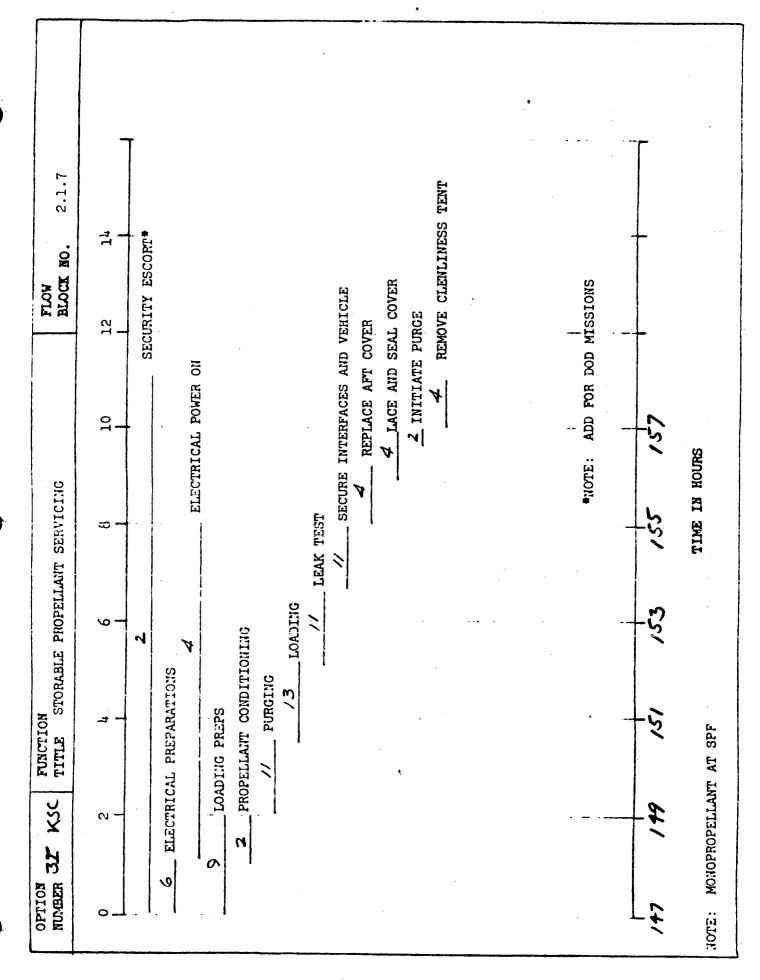
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	٧-			and the second	<u></u>	<u> </u>		_	IOURS
INTERPACES	.# <b>-</b> -	AND PLATFO		·			<u> </u>		TIME IN HOURS
VERIFY FSE INT	m=	ILICAL CONTINUITY CONTINUITY REMOVE WORK STANDS AND PLATFORMS			 		<u> </u>		
TITLE VE	- 5	r ung			 - <del>-</del>		·	167	
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OPTION 3L	o <del>-</del>	")				•		[3.	





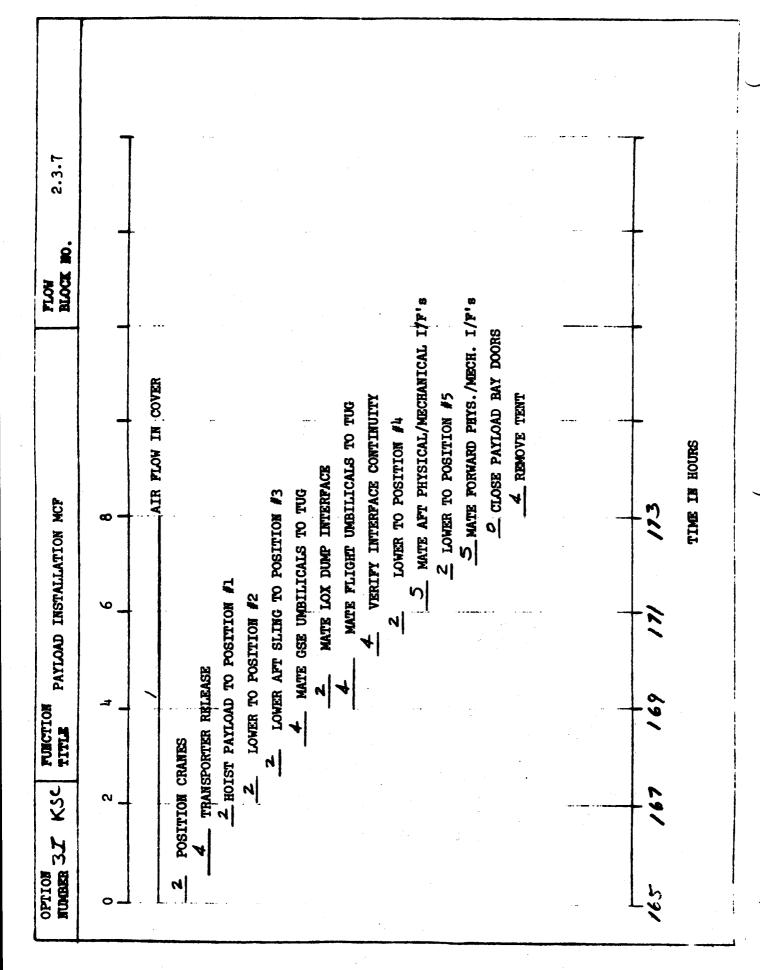
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FLOW BLOCK NO.	_				·	<b>5</b> Ω								-	
FACES	10	·		INTERPACES		GSE AND CABLES	···								· <b>m</b>
Verify Tug-to-spacecraft interfaces	& _		I FLIGHT SOFTWARE	VALIDATE SOFTWARE AND	POWER SHUTDOWN	DISCONNECT	•			<b></b>	en en en en en en en en en en en en en e			141	TIME IN HOURS
IFY TUG-TO-SPA	9	RIFY GSE	POWER ON CECRAFT FLIGHT	VALIDAT		n								139	
FUNCTION VER.	4 .	COHNECT CARLES/VERIFY GSB	POWER TEST/POWER 0	9				••	• •• •					707	
I KSC	≈_	S	4)		-								•	135	
OPTION NUMBER	0				••••							. <b>-</b>	-	TS	

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2.2.5	ω _										×						T	
PLOCK NO.	6 7	-					ORAPE	DRAPE		SEAL SEAMS	MOVE TO AIRLOCK						- 53	
	5	• . • •				VER AND DRAPE	LIFT FORWARD COVER AND DRAPE	LIFT AFT COVER AND DRAPE	LACE COVERS	3 SEAL	9					<del></del>	142	<b>9</b> 2
NESS		UNTER	TRANSPORTER	CRANES	COVERS	LIFT CENTER COVER AND DRAPE	J. LIFT FOR	11 S	4					: ·		<b></b>	141	TIME IN HOURS
VERIFY CLEANLINESS	<b>е</b> –	CHECK PARTICLE COUNTER	•	SITION	4 UNPACK COVERS	7	:						 ••••• <i>**</i>	ewie t			5	
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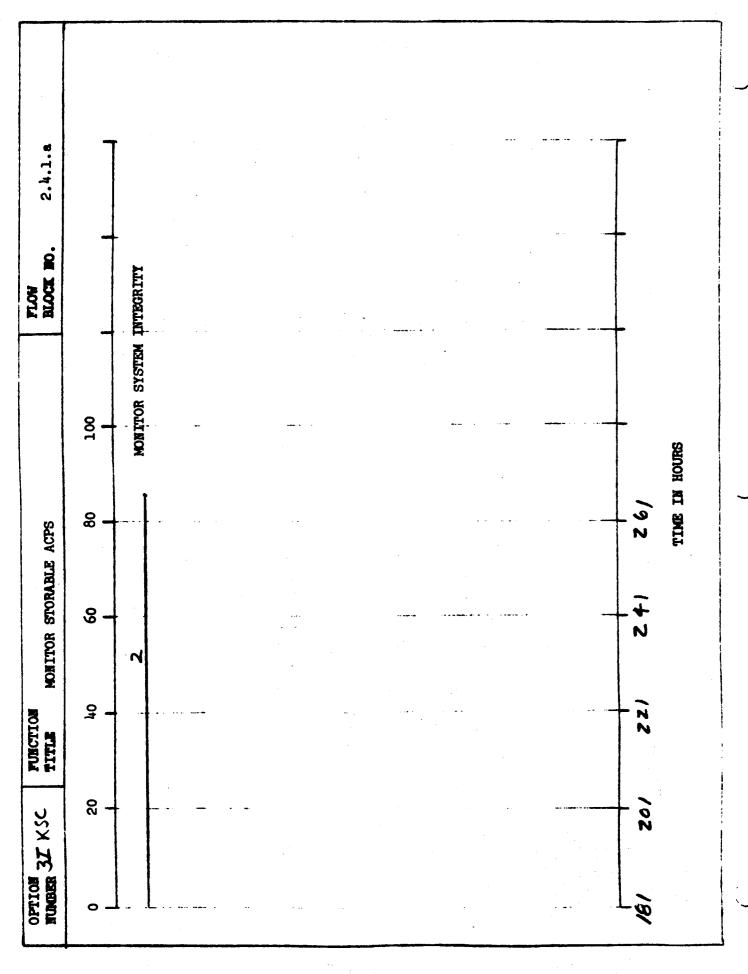


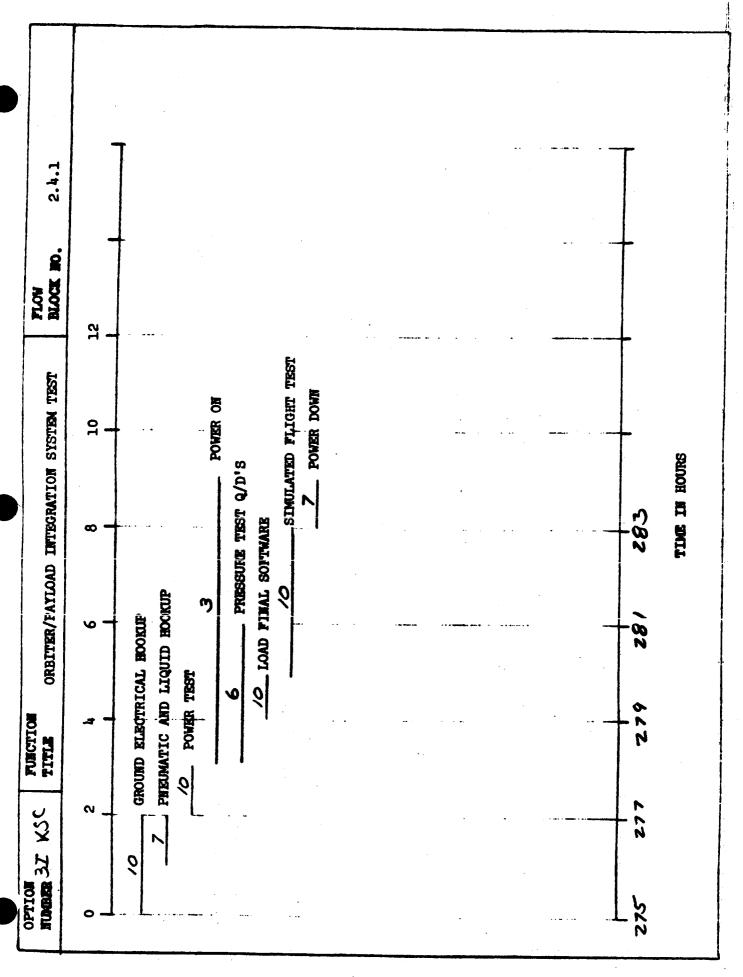
. <b>30.</b> 2.3.4										
PLOW	9 -	• ••• • .			•	manus e	MISSIONS			
	~	- •	war				 ADD FOR DOD MISSIONS		+	OURS
PAYLOAD TO MCF	2	••••••••••••••••••••••••••••••••••••••					 *NOTE:		-	TIME IN HOURS
TRANSFER PAYLOAI	e-	AREA	RANSPORTER	٠.			 		<del> </del>	
TITLE TRAN	<i>م</i> _	ATTACH TRACTOR AND CLEAR AREA  2 TRANSFER TO MCF	2 POSITION TRANSPOR			Same and the second sec			09/	
XSC X	п-	ATTACH TRAC						4. <u></u>	159	
OPTION ST.	0_	N	٨						[ 85.	

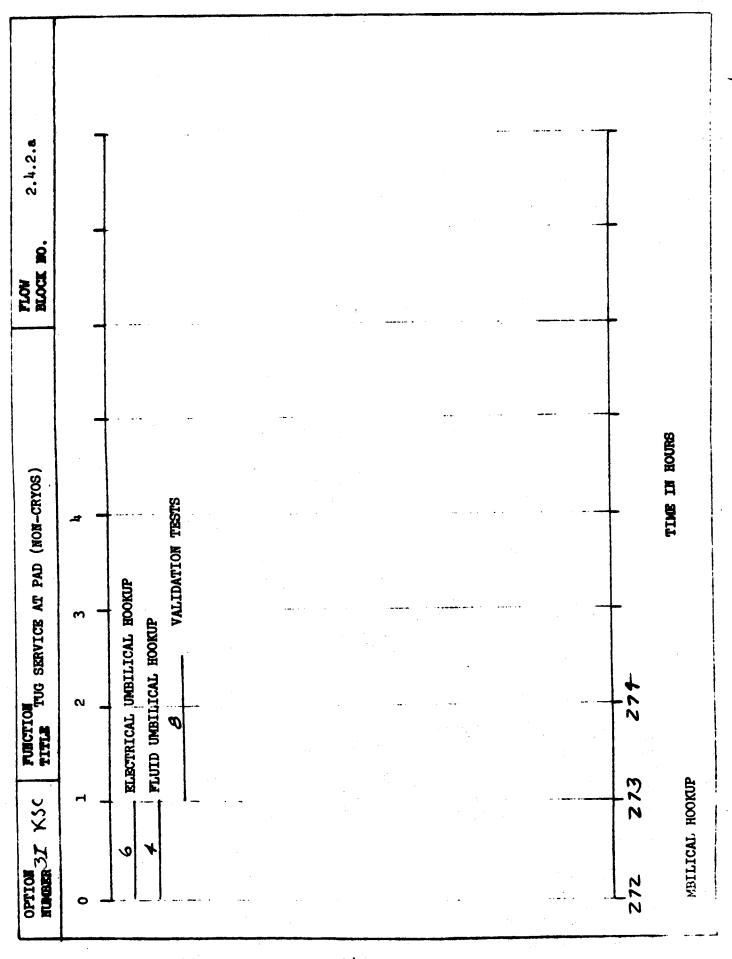
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		*	UNLACE COVERS	OGRANOV RANOVEG	ALR FLOW IN COVER	N CO VER			
	• •			POSITION WG	POSITION WORK PLATFORMS				
				ATTACE	ATTACH SLINGS			•	
				*   *	ATTACH TAG LINES	<b>S3</b>			
	٠			4		VERIFY INTERFACES READY FOR INSTALLATION	FOR INSTAL	ATION	
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				TIME IN HOURS	OURS				



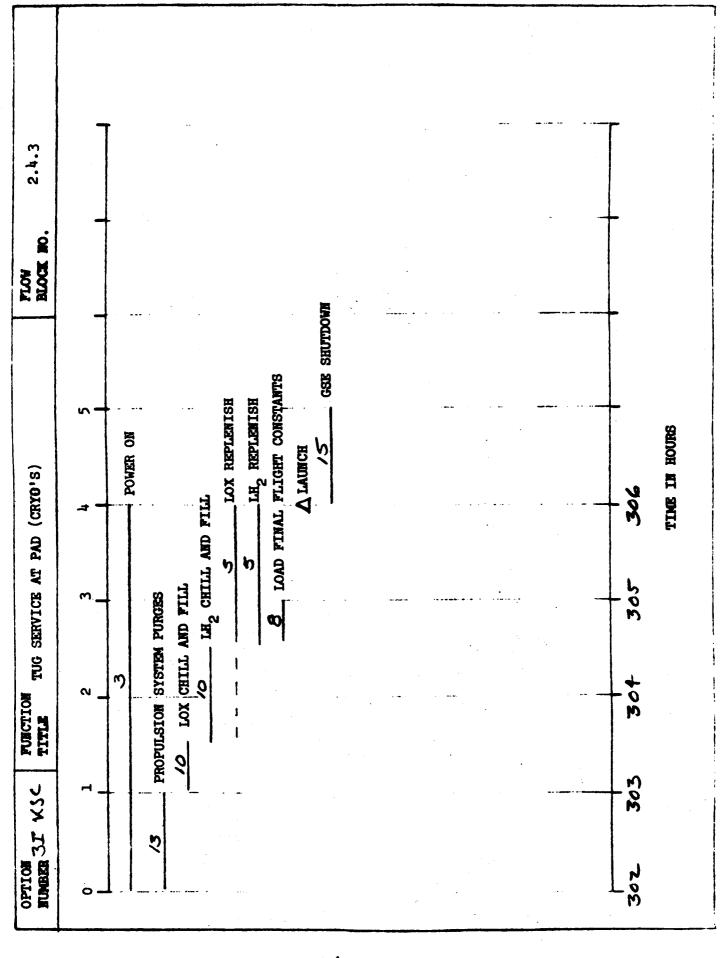
<b>.</b>																	
	2.3.9	_						ABLES					<b></b> -				
	FLOW BLOCK NO.	12 1			HT INTERPACES	ORBITER 5/5/5	0.0 /d	DISCONNECT GSE, UMBILICALS, CABLES	•		. Transmission of						
	PACES.	10	જ		(FUNCTION TEST) ORBITER FLIGHT INTERFACES	WALIDATE TUG SOFTWARE IN ORBITER	PRESCRICAL SHIPDOWN	SCONNECT GSE,	•						183		
	PAYLOAD-TO-SHUFFLE INTERFACES	8	COMMISCY UMBILICALS	•	FUNCTION TEST	VALIDATE TU	/O KIRCITRIC	9	••				- ·- ·		 181	TIME IN HOURS	
		9-		IR TEST/POWER ON IOAD FLIGHT SOFTWARE	E	9						· · · · · · · · · · · · · · · · · · ·			 179		
	FURCTION VERIFY	4 -	UP GSE, CONNECT CABLES,	POWER TEST/POWER										· .	711		
-	XX	~	SET			. <del></del>							• ·		125		
	NUMBER 3E	ا ،	0/		•					******************************					 -22/		







TUE TUG SERVICE AT PAD (MOS-CRTO)  PRESSURIZE STAGE PHEUMATICS  /2. PROPULSION STS  /2. PROPULSION STS  /2. PROPULSION STS  /2. PROPULSION STS
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SUBSYSTEM MONITYRING AT PAD	भ्रा हा ।	7		•••	 •	292 295 300	BCL
ፓ PAD	20	INOM				304	TIME IN HOURS
MOCK NO. 2.4.4		MONITOR LAUNCH REDLINES	<u></u>		<del></del> -		

TASK TIMELINES

FOR

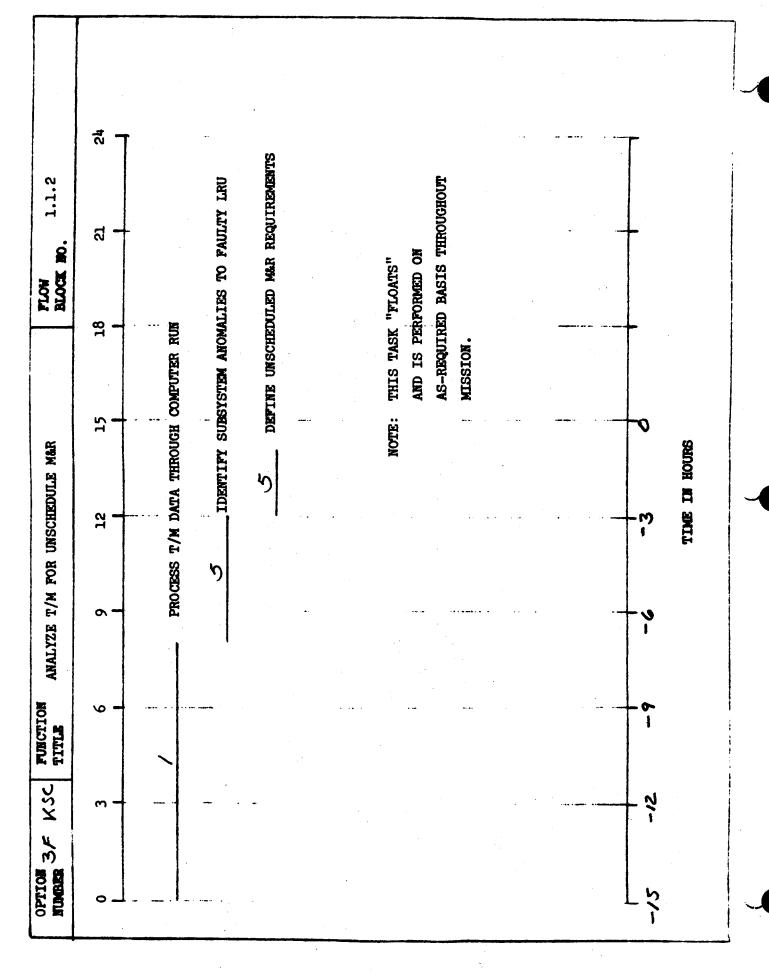
THE CRYOGENIC TUG

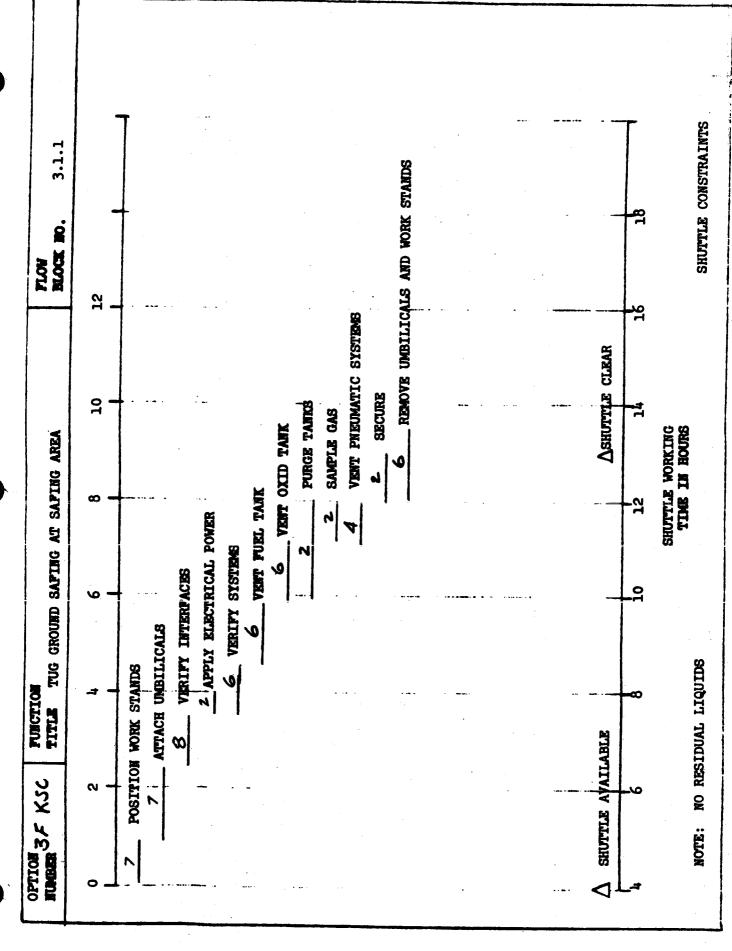
GROUND AND LAUNCH OPERATIONS

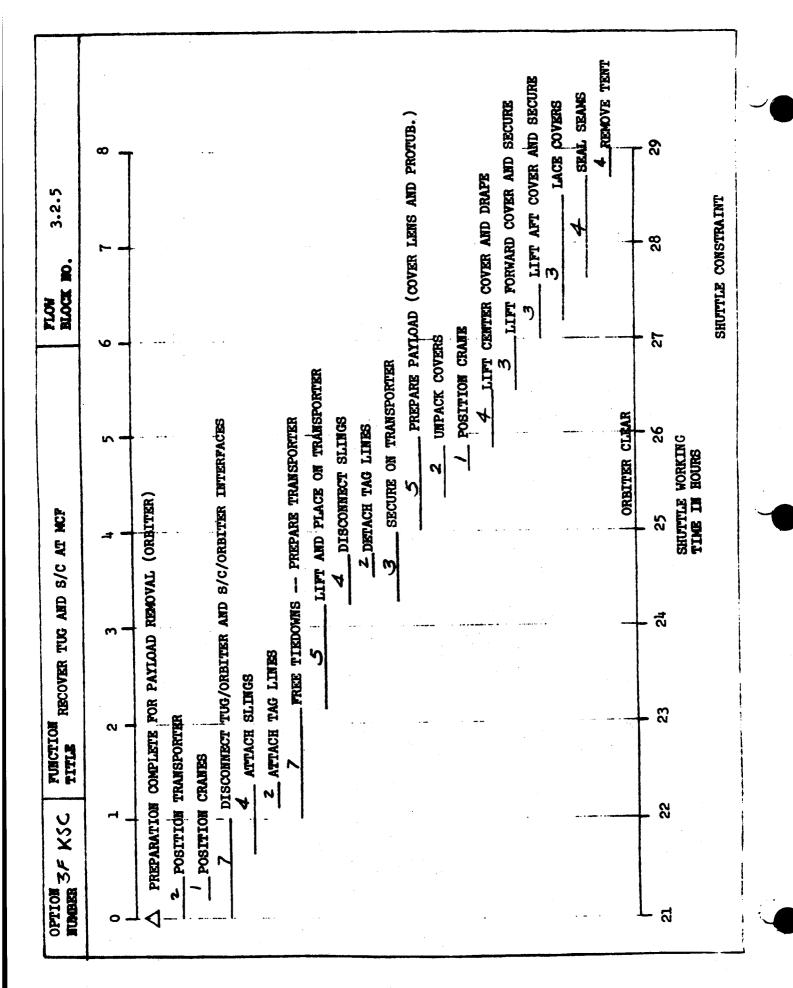
OPTION NO. 3F ETR

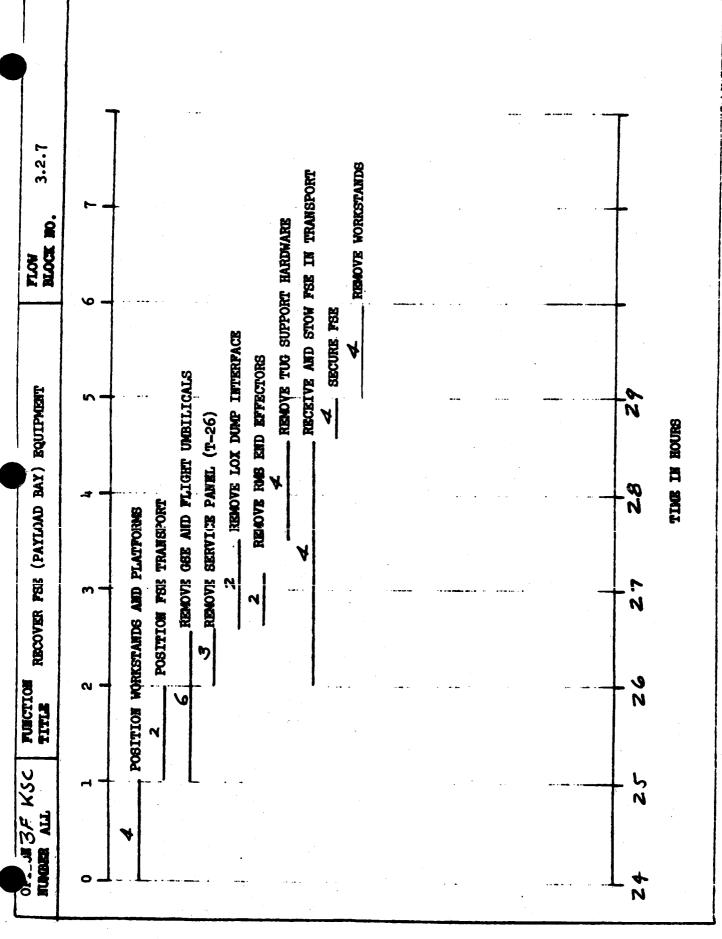
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10. 1.1.1	7 8		IDENTIFY SUBSYSTEM SCHEDULE MAINTENANCE REQUIREMENTS	INTEGRATE SCHEDULE MAINTENANCE REQUIREMENTS / PEGNADITEU DESTINIVADO COMPANY	TABLITATION OCUPOUS		DATS" AND 1 AS-REQUIRED (ISSION).			
FLOW BLOCK 1	9		BSYSTEM SCHEDULE MAI	INTEGRATE SCHEDULE		NOTE:	THIS ACTIVITY "FLOATS" AND IS PERFORMED ON AN AS-REQUIRED BASIS THROUGHOUT MISSION.	-	0	
UY MER SCHEDULE	3	MAINTENANCE RECORDS	IDENTIFY SU	8)					- 2-	TIME IN HOURS
PREPARE PRICLIMINARY MAR SCHEDULE	m <b>-</b>	REVIEW TUG"S MAIN	m	- <u></u>				·	M	
K3C FUNCTION	1 2	لا	- · · · · · · · · · · · · · · · · · · ·	•	•			· · · · · · · · · · · · · · · · · · ·		
OPTION 3 F	0_		··· <del>-</del> ·	<b></b>			• • <u>•</u>		_9	



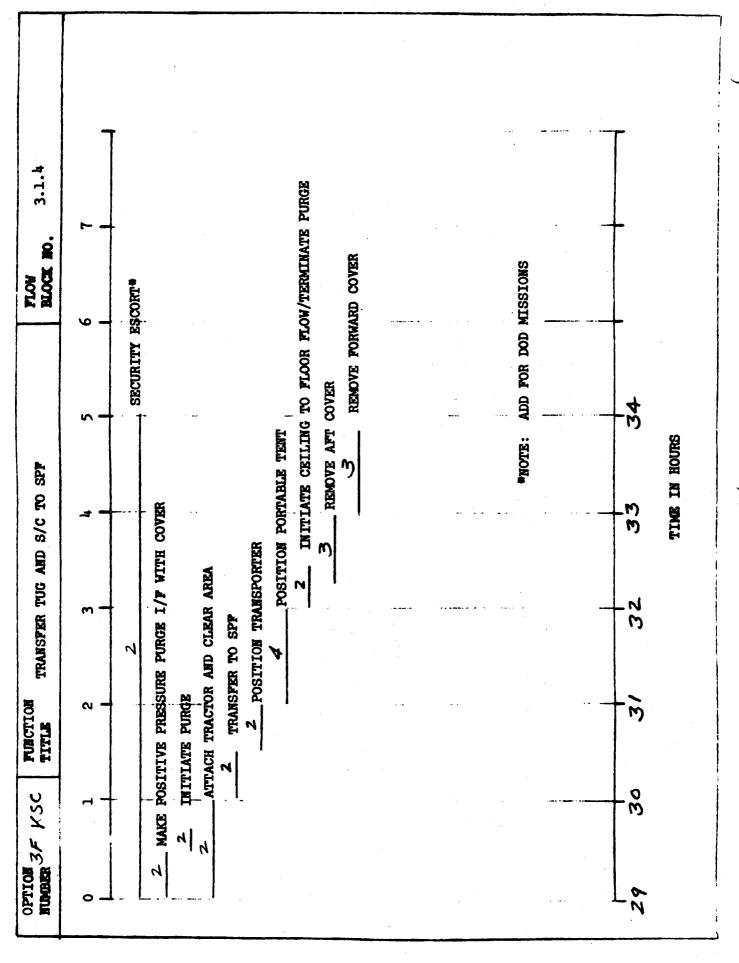






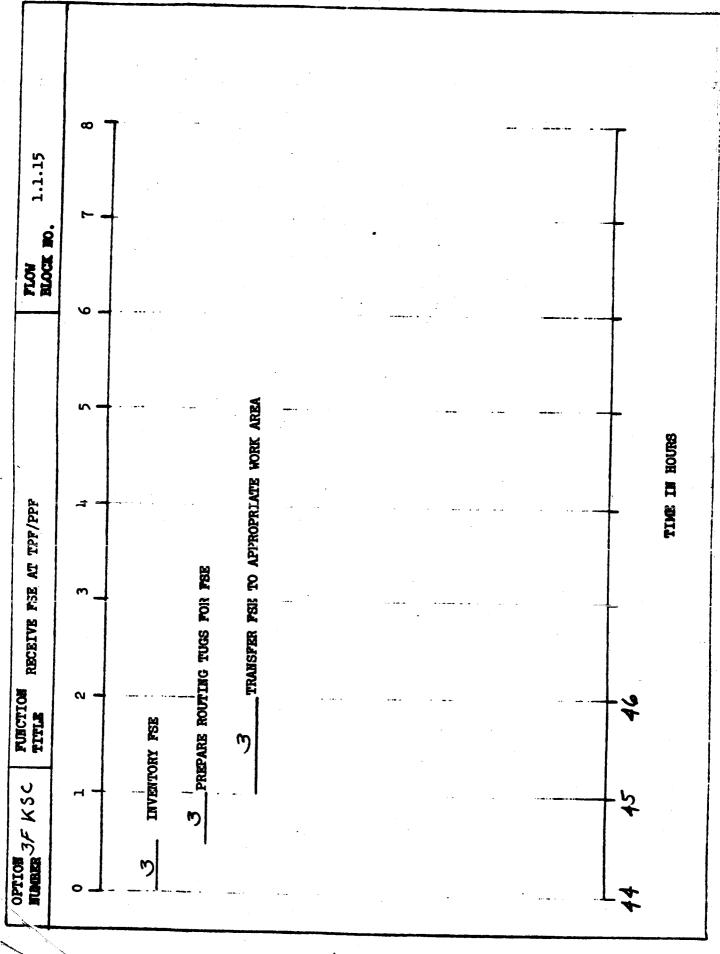
3.2.6.b			·					•			
FLOW BLOCK NO.	_	<u> </u>	<del>.</del> •			•			<u> </u>		
COMSEC)	-	• • • • •	<b></b>	C IN TRANSPORT				e de la companya de l			59
(CABIN) RQUIPMENT (COMSEC)	_		··••	RECEIVE AND SECURE COMSEC IN	••.				, e		TIME IN HOURS
RECOVER PSE (CABI	e -	AND SET UP	MESEC ROUTPMENT	RECEIVE AN	CABIN CLOSEOUR		e e e e e e e e e e e e e e e e e e e		<u>-</u>	782	
FUNCTION REC	5 -	ENTER CABIN/LOWER DECK AND SET	REMOVE CONSISC BOL	4	/ CAB			. •		27	The second secon
OPTION 3/F KSC NUMBER ALL DOD	1	2 KNTER CAI	4							- 92	

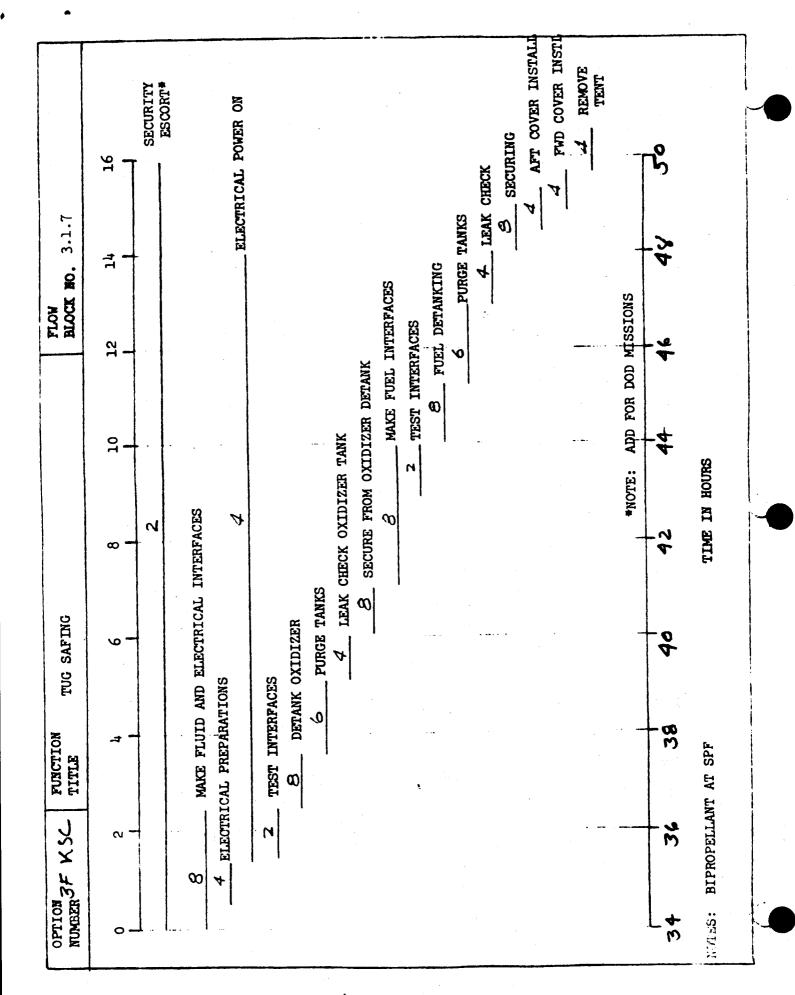
3.2.8	•		,												• • •		
FLOW BLOCK NO.	. 49 ==		· · · · · ·				WORK AREA	RLOCK	ATRLOCK FLOW		·		KISSIONS	<u></u>			
	5		•				TRANSPORT TRANSFER TO PSE WORK AREA  LINTOAD DOD PSE	TRANSPORT TO AIRLOCK	AA				ADD FOR DOD MISSIOUS	*****		37	
Jdi	<i>2</i> 2 ==			LOCK	TOW	CEMAY	RANSPORT TRANSFE	4 III				<u>.</u>	*HOTE:			36	Tiber in hours
TRANSFER FEE TO PPF	e –	ESCORT.*	. 6	POSITION TRANSPORT IN AIRLOCK	AIRLOCK FLOW	OPER ENTRYWAY	h d								_	- b	E
TO.	2 -	SECURITY ESCORT	ER CLEAR AREA	POSITION TRA		,				<b>.</b> .	<del>.</del>	·			. "	<b>*</b>	
K3c	н -	7	TRANSFER CLEAR AREA  2 TRANSPORT TR	r '	• •									. <b></b>		33	
OPTION 3F	0 _		7	·			•••					•		••••• •	<b>.</b>	32	

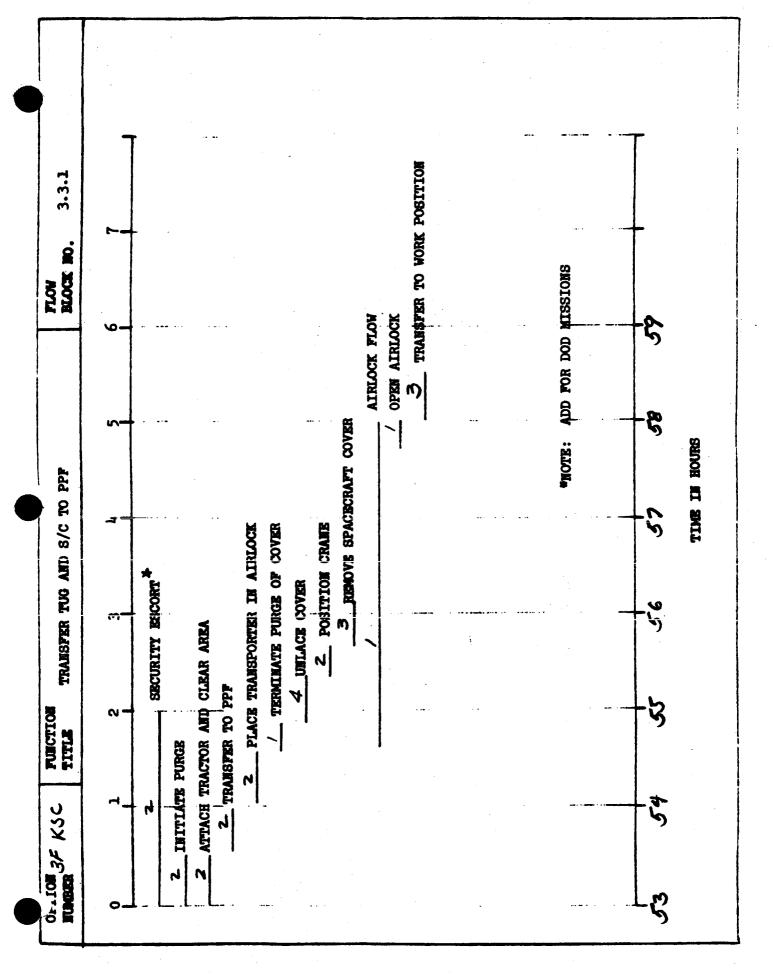


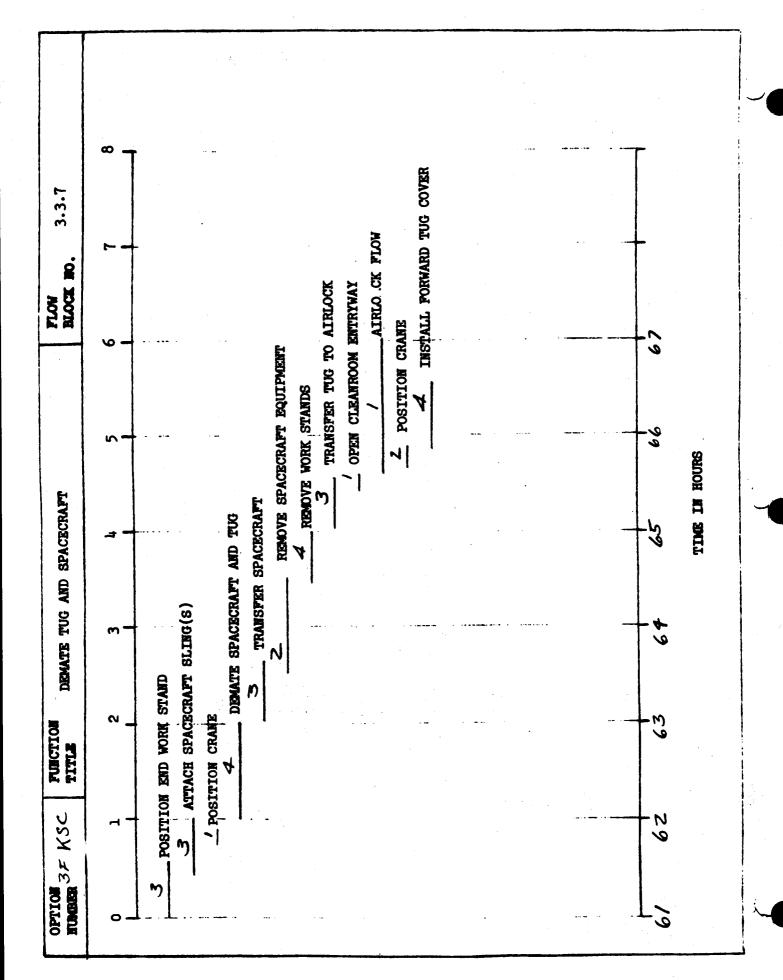
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3.2.9	•				<u>.</u> .											T	
Ö.	-								AIRLOCK						*	+	
BLOCK	9 -		<u>.</u>				TRANSPORT TRANSPER TO PSE WORK AREA	33	TRANSPORT TO AIRLOCK		rember •	• • • • • •		· ••@difference	ale alled services	_	
	· · · ·	, <u>.</u> .	• .				FER TO FSE	UNITOAD PEE	7							w	
							ORT TRANS	S UNITORI		•						*	TIME IN HOURS
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TRANSFER FSE	m <b>-</b>		TO TPF	POSITION TRANSPORT IN AIRLOCK	ATRE	/ OPER	1	****			· · · · · · · · · · · · · · · · · · ·		e e santa			14	
	٦ م	IR AREA	TRANSPORT TRANSFER TO TP	OSTRION TR							to dan ser				1810 - 1 andres	40	
TITIE	٦ -	TRANSPORT CLEAR AREA	<b>-</b> ]	4										ne tollessorie		- 6-	
SUMBER		7 TRA	7					•						•		36	
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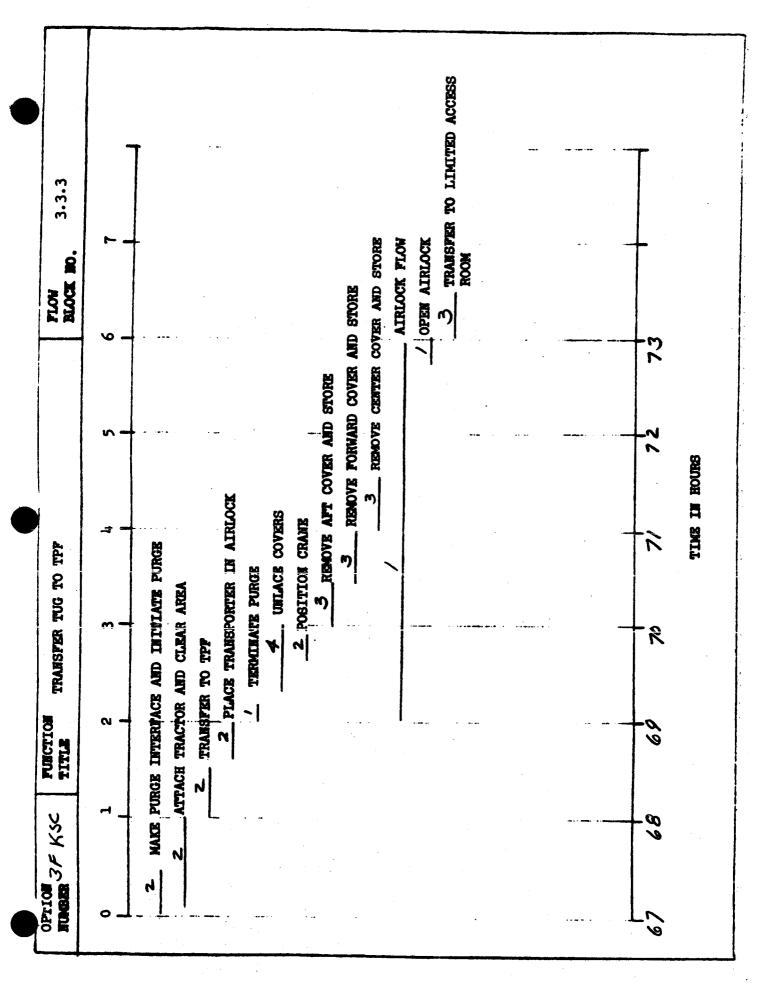
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1.1.3	8	INTEGRATE SCHEDULED AND UNSCHEDULED MAR REQUIREMENTS	CHEDULE			
PLOCK NO.	F	UNSCHEDULED 1	UPDATE M&R SCHEDULE			
	5 6	SCHEDULED AND			 - 7	
		INTEGRATE				THE IN HOURS
M&R SCHEDULE	m <b>-</b>			 an an	, II	
FUNCTION UPDATE MAR	5	٧.		en en en en en en en en en en en en en e		9 9
255	F4					55 50
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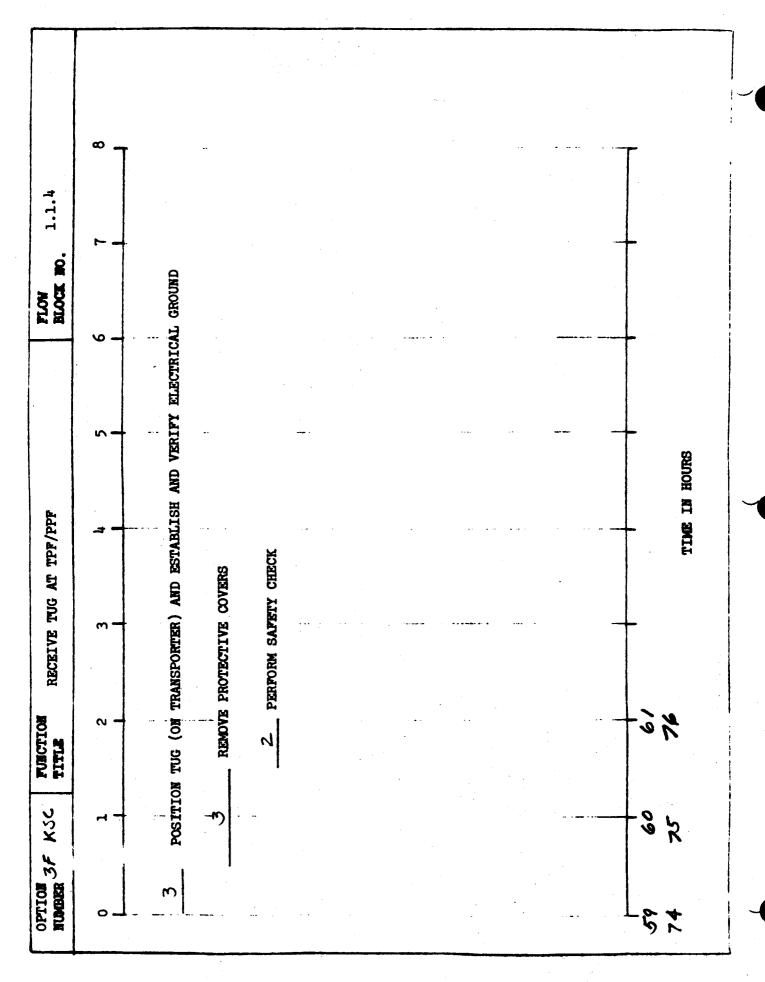




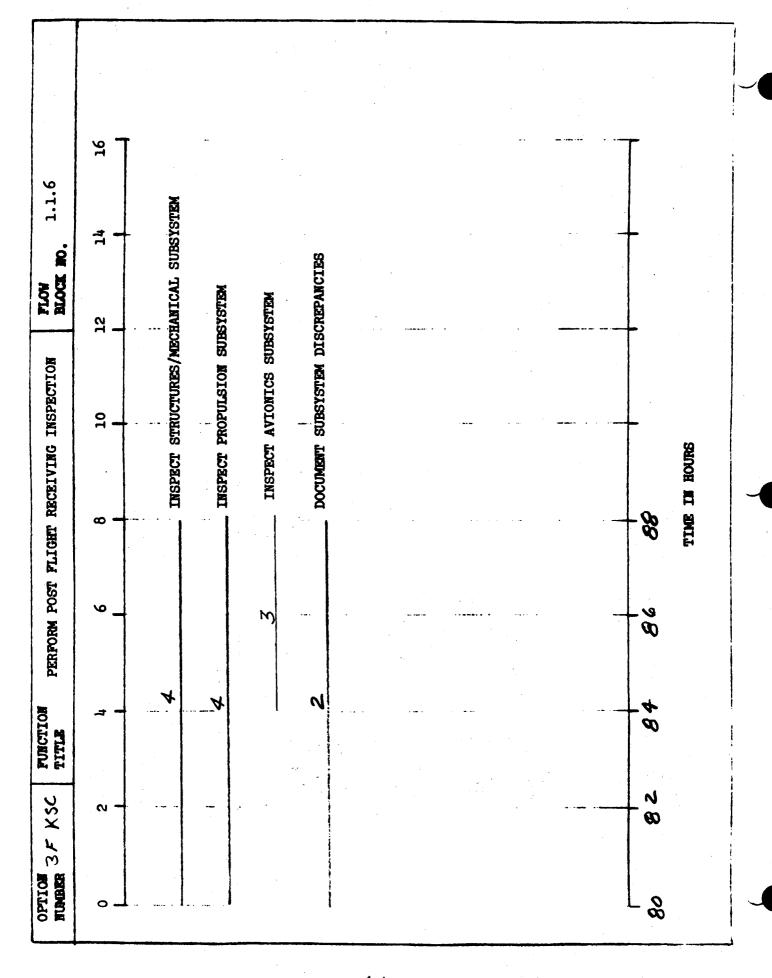


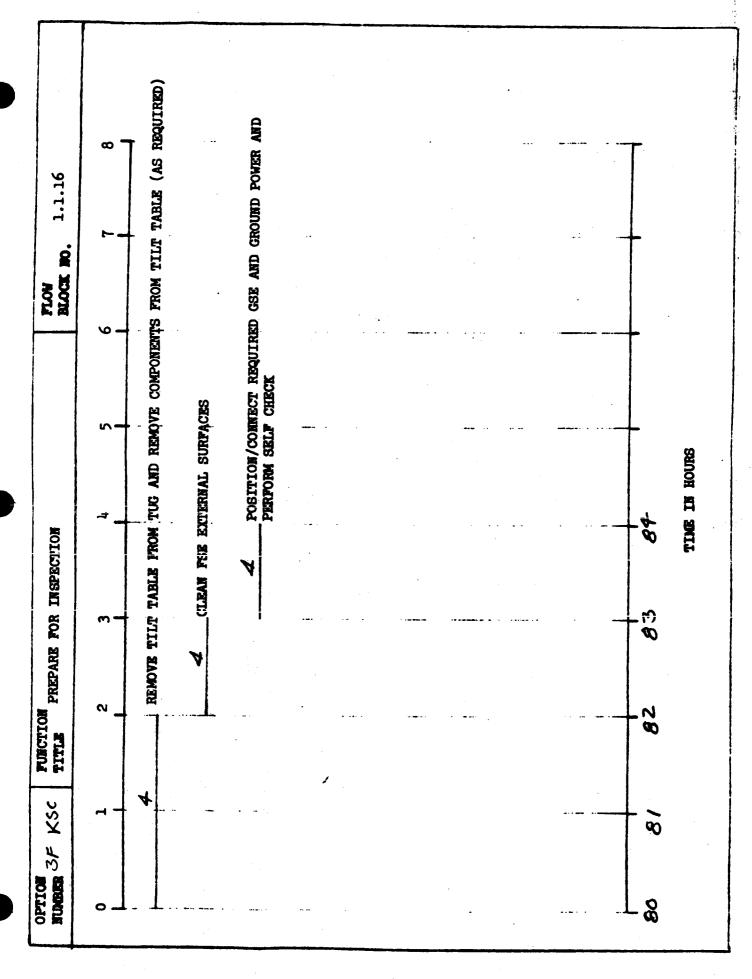






TAMIDS  TAMIDS	CCESS PANELS/DOORS  STALL AIR CONDITIONIN  A  REMOVE: FORW  79  80	TIME IN
TANDS  TANDS  TINSTIT  S  TINS	ACCES 68	<u>-</u>
ORIGO (V)	KSC TITLE  POSITION WORKSTANDS  6 OPEN A  77 78	



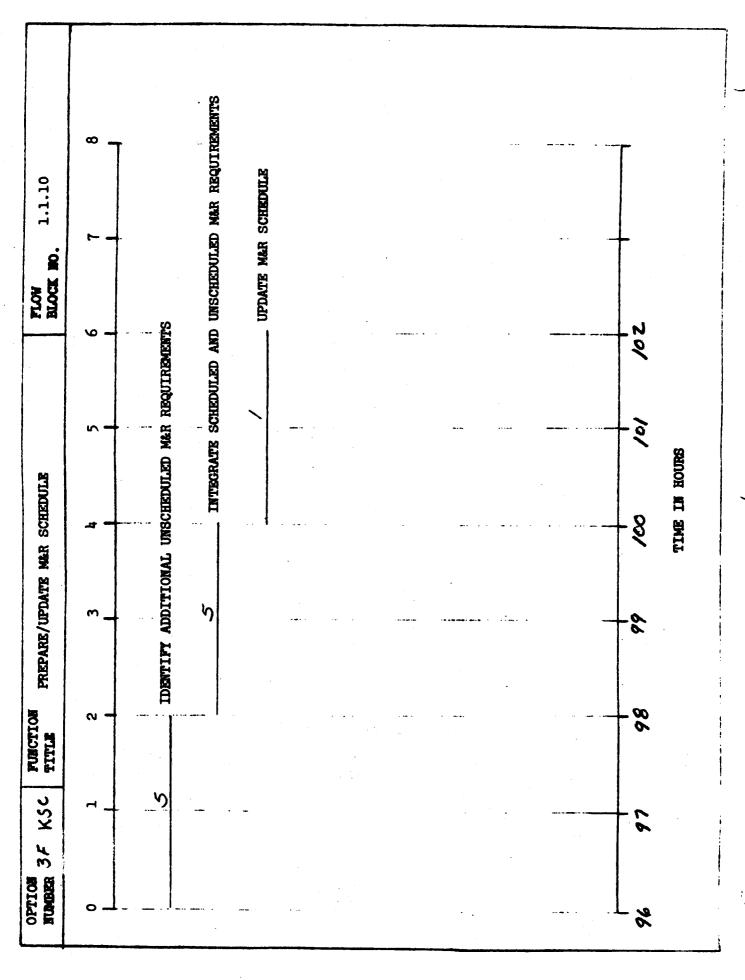


8 9	T TABLE INSPECT CAUTION AND WARRING INTERFACE EQUIPMENT	CT RMS SUPPORT EQUIPMENT  2 TECTION WITH HANY LOAD	4 INSPECT ELECTRICAL UMBILICALS	DOCUMENT FSR DISCREPANCIES		• • • • • • • • • • • • • • • • • • • •	96 #6	TIME IN HOURS
	3 INSPECT TILT TABLE 2 INSPECT CAUT	Z INSPECT RMS	*	N			90 92	

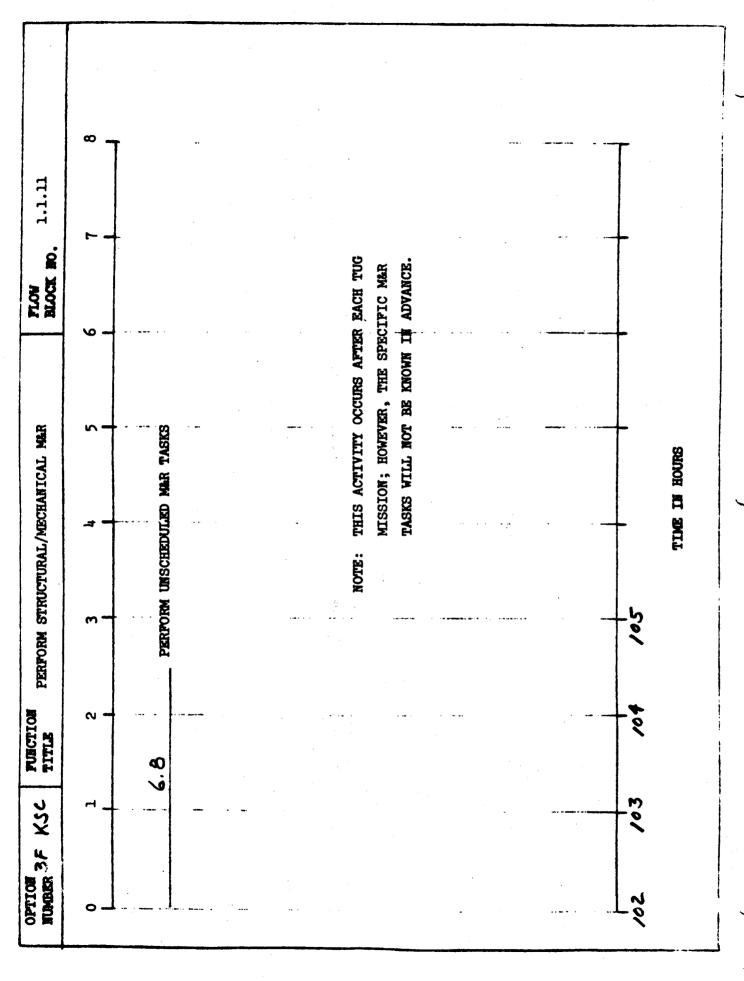
C RIZ	6 8 10 12 14 16 1 1 1 1		IL LEAK CHECK TO ISOLATION VALVES INTERNAL LEAK CHECK OF ISOLATION VALVES	į			96 66
	<b>3</b>	POWER UP PREPARATIONS  TEST SET UP  MAIN TANK PRESSURIZ	S EXPERSION		 · · · · · · · · · · · · · · · · · · ·	. 11	26

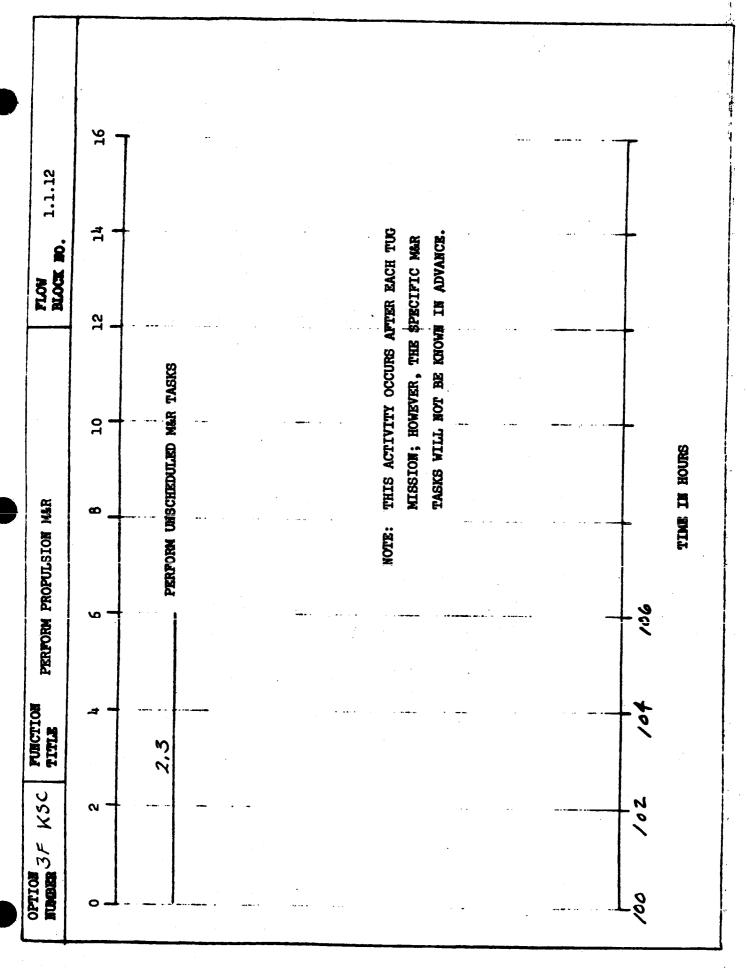
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	~ -	# <b>-</b>	<b>%</b> -	∞ -	0 -	12 14 1	16	
POW	POWER ON PREPARATIONS	RATIONS						
7	かは	TEST SET UP			e. e	• • •		
	الم		PRESSURIZE HELI	UM BOTTLE				
	- -	-	8	REGULAS	REGULATOR AND ISOLATION VALVE REGULATE PRESSIRE AND LOCK IP	LVE FUNCTIONAL	RECULATOR AND ISOLATION VALVE FUNCTIONAL AND INTERNAL LEAK CHECK RECHILATE PRESSIRE AND LOCK IP	ECK
				7	PRESSURE SWITCH CHECKOUT	KOUT		
					5 PRESSURIZE LO	PRESSURIZE LOW PRESSURE SYSTEM	MS	
					5 THRUSTER	THRUSTER VALVE FUNCTIONAL CHECK	L CHECK	····
		** . · .			\$	PROPELLANT	PROPELLARY ISOLATION VALVE FUNCTIONAL	LIONAL.
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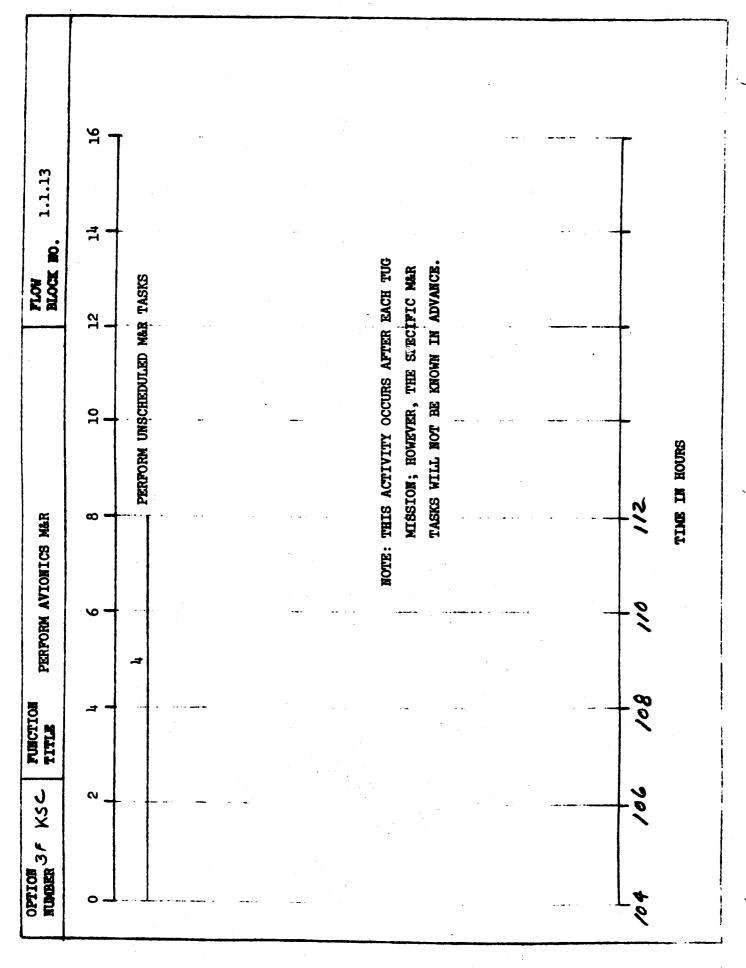
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1.1.7.9	_							e in the second	CHT.			
PLOW BLOCK NO.	-	<u></u> .			턵		T 68E	APPROXIMATELY 1/3 OF INSTRUMENTATION	PROPULSION AND AVIONICS POST FLIGHT CHECKOUTS TO BE RUN CONCURRENTLY.			
S	0†			TION	ALL SYSTEMS TEST	POWER OFF	DISCONNECT	APPROXIMATELY 1/3 OF INSTRUMEN CALIBRATED AFTER EACH MISSION.	ON AND AVION S'TO BE RUN		4	· A
JT - AVIONICS	ક્ષ –	CABLES		CALIBRATION	S ALL	<b>\</b> 1	<b>n</b>		2, PROPULSI CHECKOUT		36	TIME IN HOURS
IGHT CHECKOUT	24 1	AND CONNECT CABLES		6)		• "	18 dalain	HOTE: 1		;	7 82/	er Er
POST PLIGHT	16 ;	INTERFACES	RN ON	·y							20 /	
C TITLE	8	VERIFY GSE	POWER TURIN ON					• • • • • • • • • • • • • • • • • • •			1112 11	
NUMBER 3F KSC		Ŋ									88 96,	• •



TIPT ADDITIONAL UNSCHEDULED MAR REQUIREMENTS  S  INTEGRATE SCHEDULED AND UNSCHEDULED MAR REQUIREMENTS  PREPARE/UPDATE SCHEDULE  PREPARE/UPDATE SCH		2	m-	==	~		9	-	8 -
	IDENTIFY AD	DITTORAL 1	MSCHEDULE NTEGRATE	D MAR RES	QUIREMENTȘ AND UNSCHEI	WLED MER	REQUIREMEN	- ඩි	
2				PR	EPARE/UPDATE	SCHEDULE	·		
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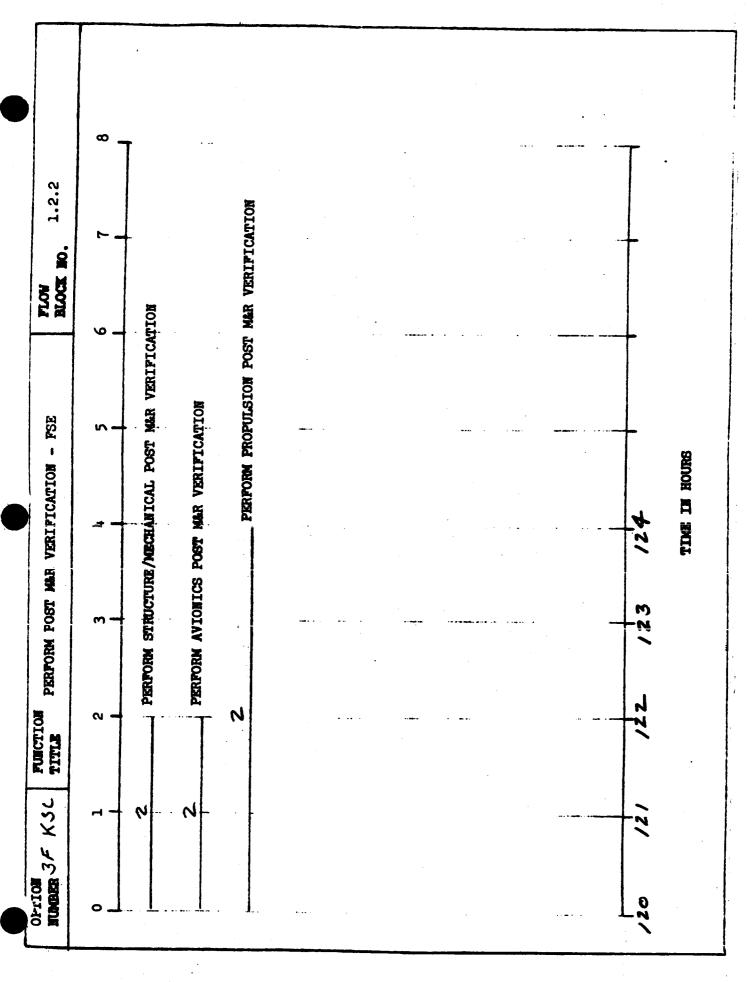


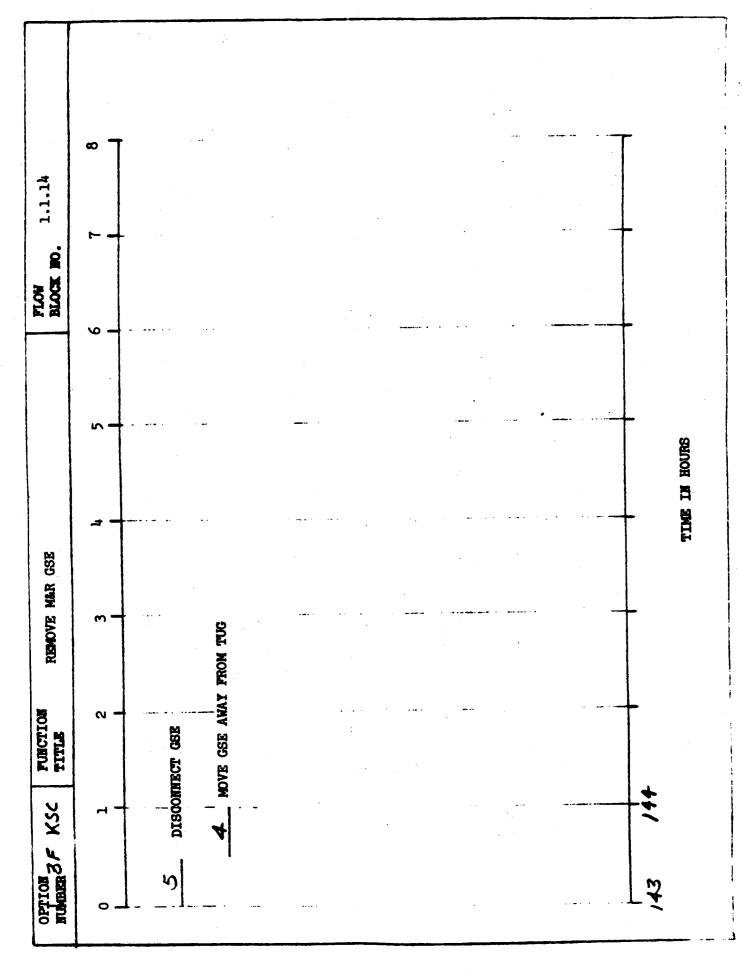




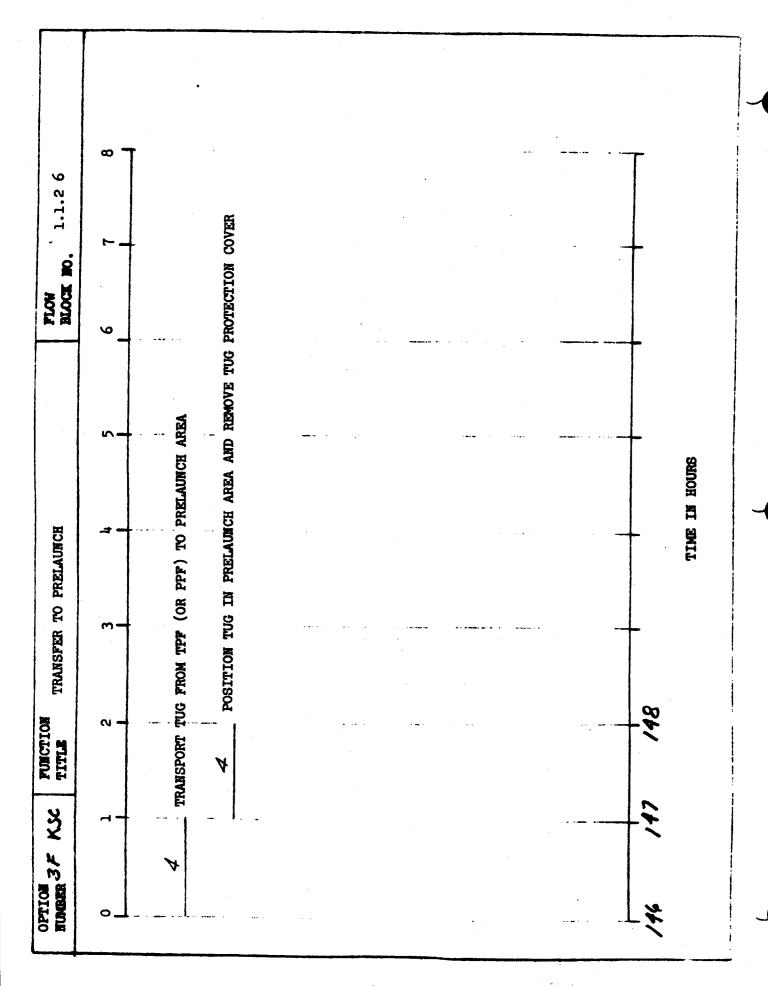
K5C FUNCTION PSE 14.8  4 8 1.2  /	FLOW 1.1.19 BLOCK NO. 1.1.19	16 20 24 28 32 1 1 1 1	PERPORM UNSCHEDULED STRUCTURAL/MECHANICAL MAR	PERFORM UNSCHEDULED AVIONICS MAR	PERFORM UNSCHEDULED PROPULSION MAR	CLEAN AND PACKAGE PLUID UMBILICALS	THES ACTIVITY OCCURS AFTER EACH TUG MISSION; HOWEVER, THE MAGNITUDE OF INDIVIDUAL SUBSYSTEM UNSCHEDULED MAR TOGETHER WITH RELATED SKILL REQUIREMENTS WILL VARY.		02/	TIME IN HOURS
X 2	(	27 -				<b></b> .	 NOTE:		 9//	
	PITLE PERFO	8		/	'	'	 		 1/2	
	WEIGHT KSC	4		-				•	 80/	

2 PERPORM STRUCTURES POST MAR VERIFICATION  2 PERPORM AVIONICS POST MAR VERIFICATION  2 PERPORM AVIONICS POST MAR VERIFICATION  (1) /// // // // // // // // // // // // /	2 2	2	M							
PERFORM STIRU	2 2	-	, -	_++ <del>-=</del>		<i>ادر</i> -	9 -	<b>-</b>	ω <b>-</b>	
2		STRUC	TURES POST M	AR VERIFICA	ATION		• * <del>- • -</del> • •	•		
A// ///		<u> </u>	erform propu	LSION POST	MAR VERIFI	CATION				
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TIME IN HOURS	/// 9//	1/2				-	-	_	-	
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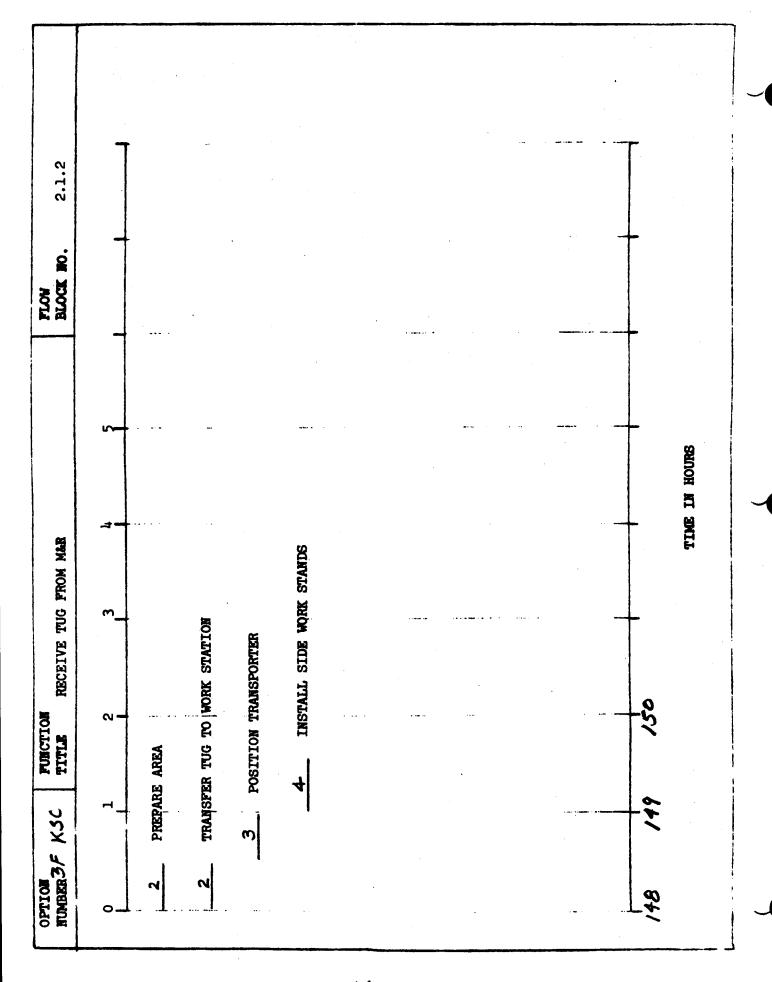




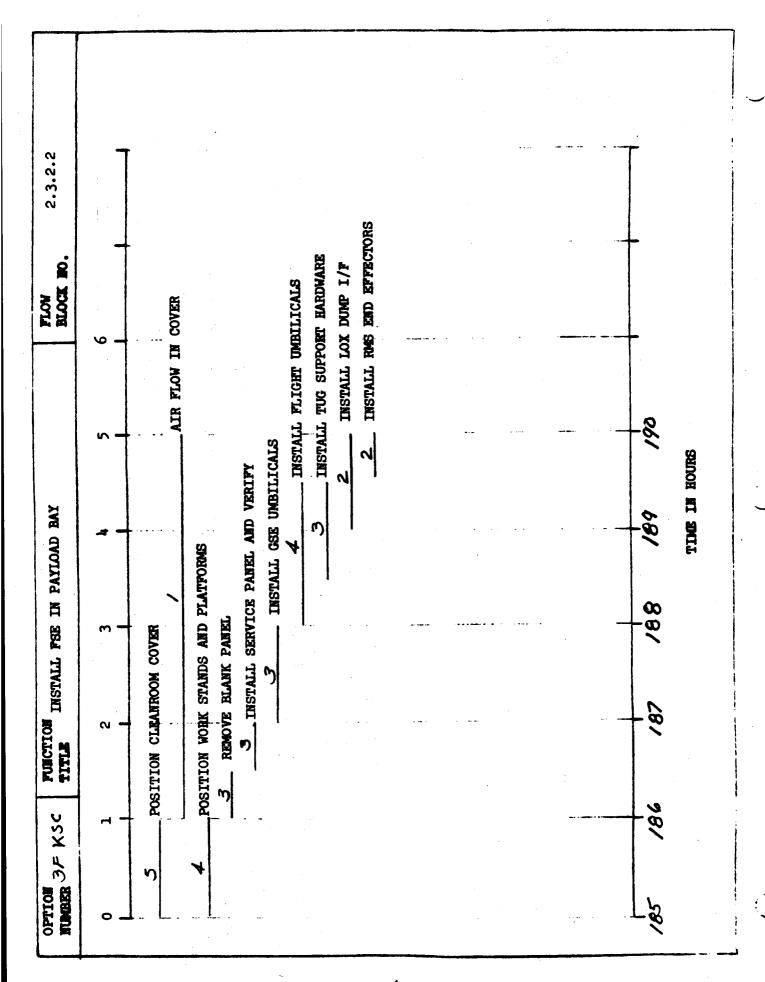
	BUREAGE	TITLE	FREFANG 1	FREFARE FOR TRANSFORT		闰	BLOCK NO.	1.1.2 1	٠.	
0_		- 5	3	<b></b>	· w=	<b>%</b> -	-	<b>6</b> 0 `		
4	- <u>-                                  </u>	OSE AND SE	CLOSE AND SECURE ACCESS	PAIRLS		. <u>-</u>		·	-	
· —— ·		L INSTA	LL TUG PROT	INSTALL TUG PROTECTIVE COVER	<u></u>					
	··•	4	CLEAR AREA	AND HOOK UP T	WID ROOK UP TO PRING MOVER					
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*	145	148					+			
				TDE	TIME IN HOURS					

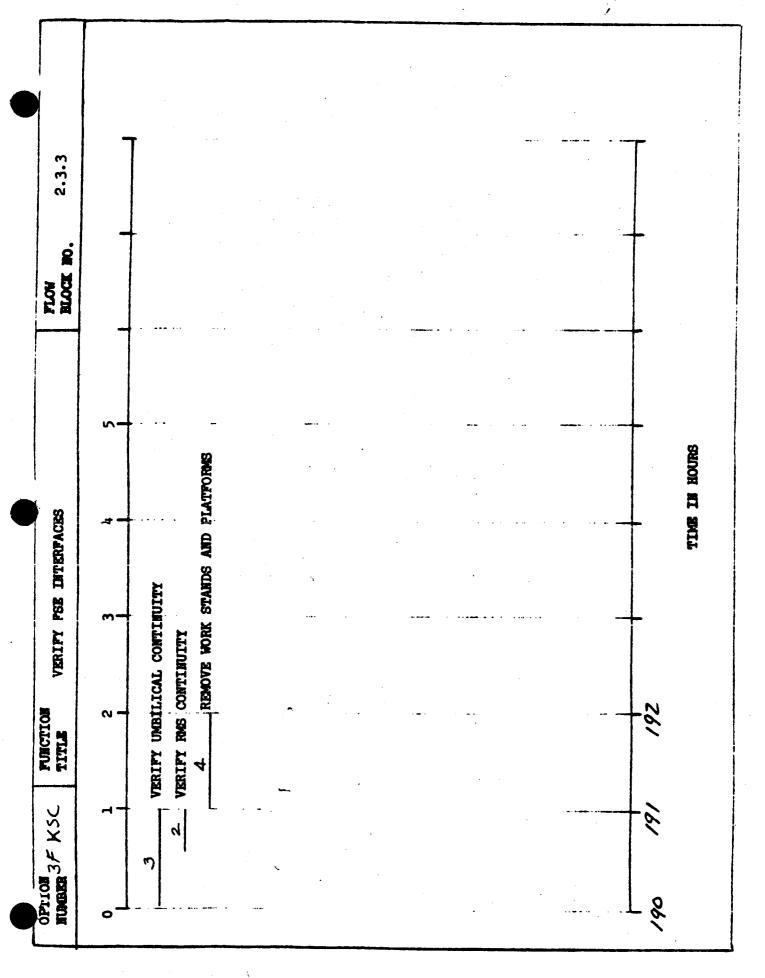


4	- 5	<b>ـ</b> ع	ਜ ਜ	5	9	-
PREPARE A	REA AND GSI	PREPARE AREA AND GSE TRANSPORT				
TRANSFER	TRANSFER GSE UNBILLICALS TO		NORK POSITION			
3 IOAD	GSE UMBILI	LOAD GSE UMILLICALS INTO TRANSPORT	RAMSIPORT	<u>.</u>		
7	TRANSFER FLIGHT		ILICALS TO	IMBILICALS TO WORK POSITION		
- <del>-</del>	LOA	LOAD FLIGHT UM	BILICALS IN	UMBILICALS INTO TRANSPORT		
	`	2 TRANSFE	R SERVICE 1	ISFER SERVICE PANEL TO WORK POSITION	NOITION	
		2 10	AD SIERVICE	LOAD SERVICE PANEL INTO TRANSPORT	UNSPORT	
		. 1	2 TRANS	TRANSFER LOX DUMP INTERPACE	TERFACE	
	<b>.</b>		2 10	AD LOX DUMP I/	LOAD LOX DUMP I/F INTO TRANSPORT	
			ī	4 TRANSFER CC	4 TRANSFER COMSEC AND CONSOLE	
				104	႙	Pa Pa
	. <u>.</u> .				2 SECURE TRANSPORT	<b>E</b> e
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163	164	165	166	167		



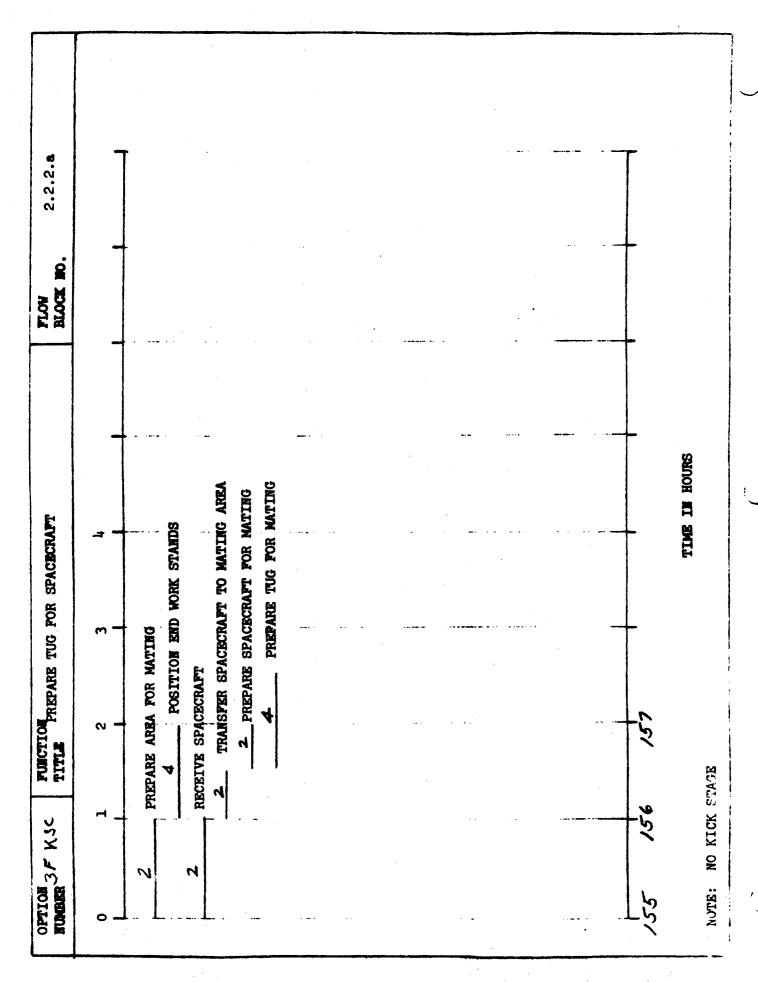
SECURITY ESCORT* SPORT CLEAR AREA TRANSPORT TO MCF  2 POSITION TRA  3 3	TRANSFER PSE TO MCF 2.3.1 BLOCK NO.	3 4 5				NSPORT IN MCF AT ORBITER AREA	SET UP PAYLOAD BAY CLEAM COVER	PREPS FOR UNLOADING PSE	6 UNICOAD PSE			WIOTE: ADD FOR DOD MISSIONS		173 174	
- 1		2 -	CURITY ESCORT*	TRANSPORT CLEAR AREA	TRANSPORT TO MCF	2 POSITION TRANSPORT		1	•		 			- 22/	•

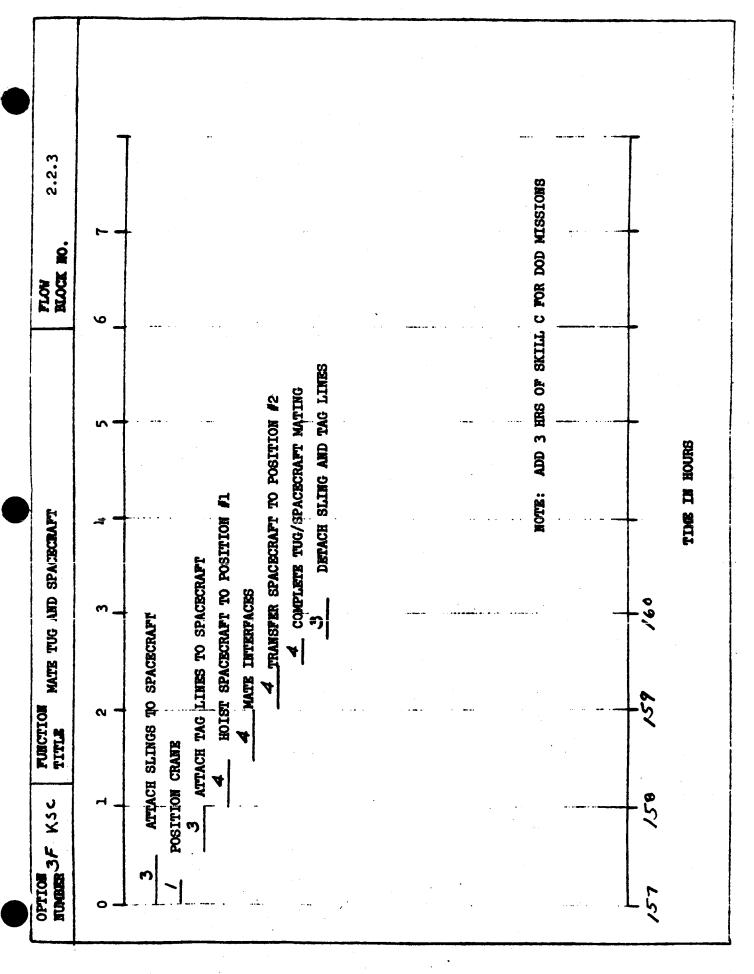


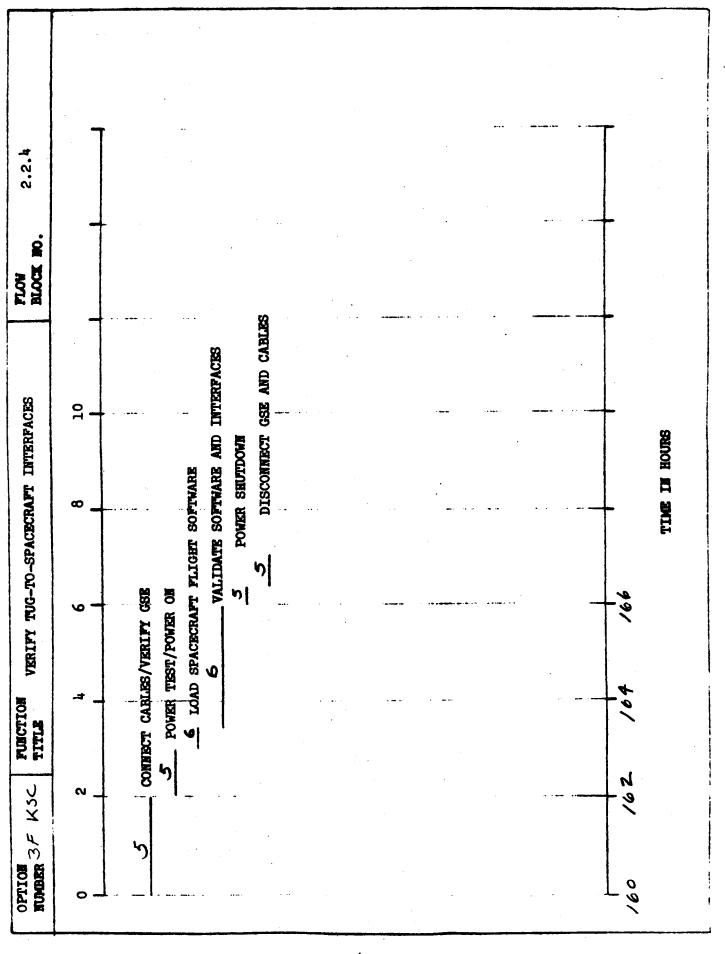


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BLOCK NO.	-						·			•			
	5		•			····			•				
			B DRAPE	AFT COVER AND DRAPE	ers Seal beans								TIME IN HOURS
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TITIE	c =	UNPACK COVERS	LIFT CENTER COVER	Τ '	<b>1</b>		 <del></del> 1	·	e .		·	6+1	
	٦.	Z UNPAC	4	_	-			ž .			-	148	
NUMERICA	o -		- ••		: .	,	•					147	

4.	-	· T											· p	 Τ	
FLOW 2.1.4 BLOCK NO. 2.1.4	-									te:					
	2		•		•				. XI	TRANSFER TO WORK STATION					RS
TUG TO PPF	4 -	2	R ARRA		ANSPORT IN AIRLOCK	ATRLOCK FLOW	VE FORWARD COVER	CRANE	/ OPEN ENTRYWAY	Z TRAIS		e de la companya de l	•	 + 1855	TIME IN HOURS
IOH TRANSFIER	2 - 3	RFACE AND VERIF	TIATE PURGE ATTACH TRACTOR AND CLEAR AREA	TRANSFER TO PPF	POSITION TR	,	4 REMOV	POSITION /						 153 13	
F KSC TITLE		MATE PURGE INTERFACE AND VERII		2 H	7						·			 152 /	
NUMBER 3F KSC	٥	2	. 2										• • ••	- <i>b</i>	







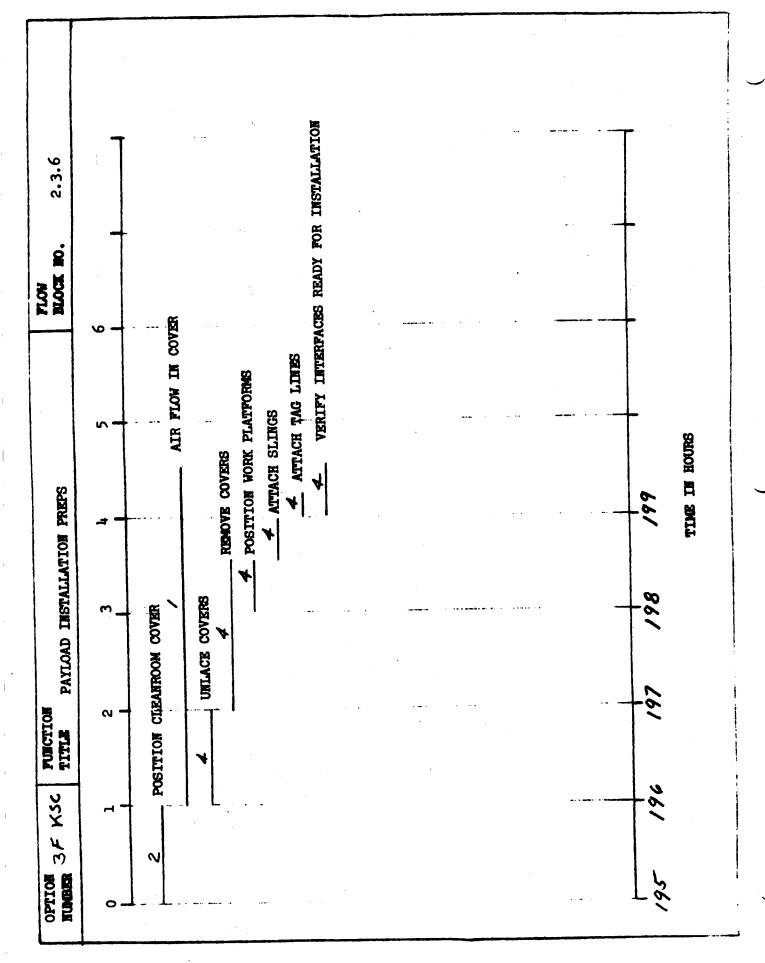
HUBER 3F KSC	70	TITIE	ABUTEI	VERLET CLEANILLINES				BLOCK NO.	۲۰۶۰۶	
0	r-1 -	5 -	3		<b>4</b> =	2	<b>9</b>	-	7	∞ -
			CHECK PARTICLE COUNTER	CLE COUNT	Æ					T
	······································	l.	2 POSITION	ON TRAISPORTER	)RTER					
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			ţ	A LIF	LIFT CENTER COVER AND DRAPE	OVER AND	DRAPE			
				<b>.</b>	Ì	NEWARD COV	LIFT FORWARD COVER AND DRAPE	<b>LPE</b>		
					2	IFF AFF C	LIFT AFT COVER AND DRAPE	ORAPE		
					4		LACE COVERS			
		•			1	a)	SEAL SEAMS	SEAMS MOVE TO AIRLOCK	RLOCK	
		• <b>66</b> .					PRESENTATION OF	÷		
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*	165	99/	167		-89	69/	170		-	Γ
					TIME IN HOURS	<b>38</b> C				

2.1.5															
FLOW BLOCK NO.	6 7								fromena ser. •		ONS			_	
	2	• • • •		· .	SS TIENT		REMOVE AFT COVER SECURITY ESCORT*			<b>.</b>	ADD FOR DOD MISSIONS	was than to			SE
o to spr	,# <b>-</b>				SPORTER POSTTION CLEANLINESS TENT	INITIATE FLOW					*NOTE: A	:		411	TIME IN HOURS
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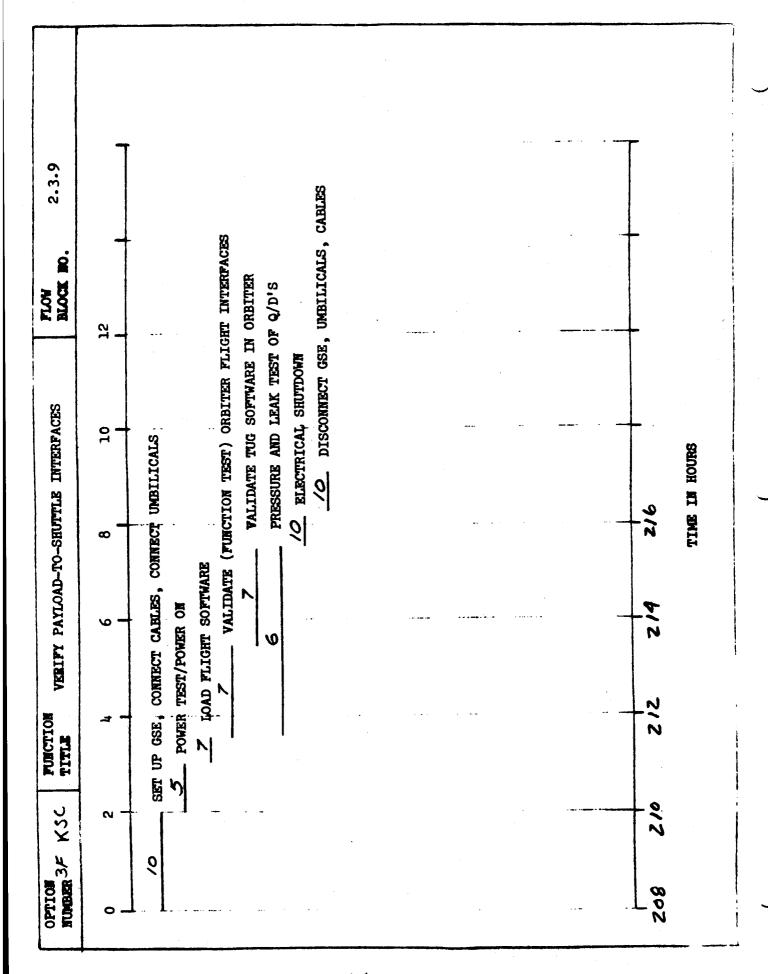
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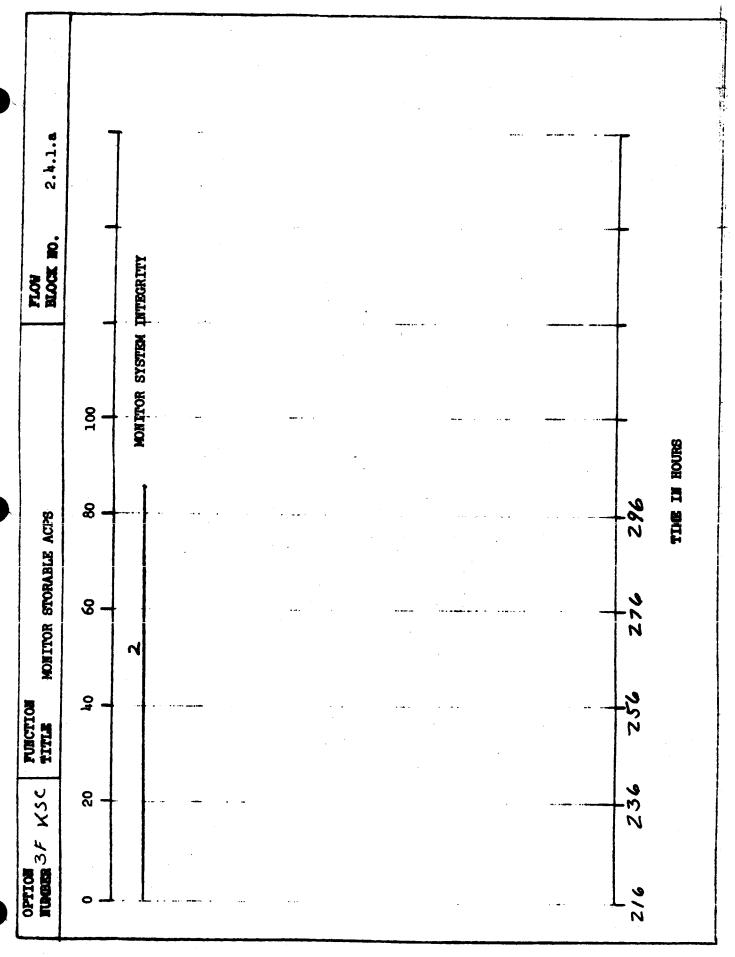
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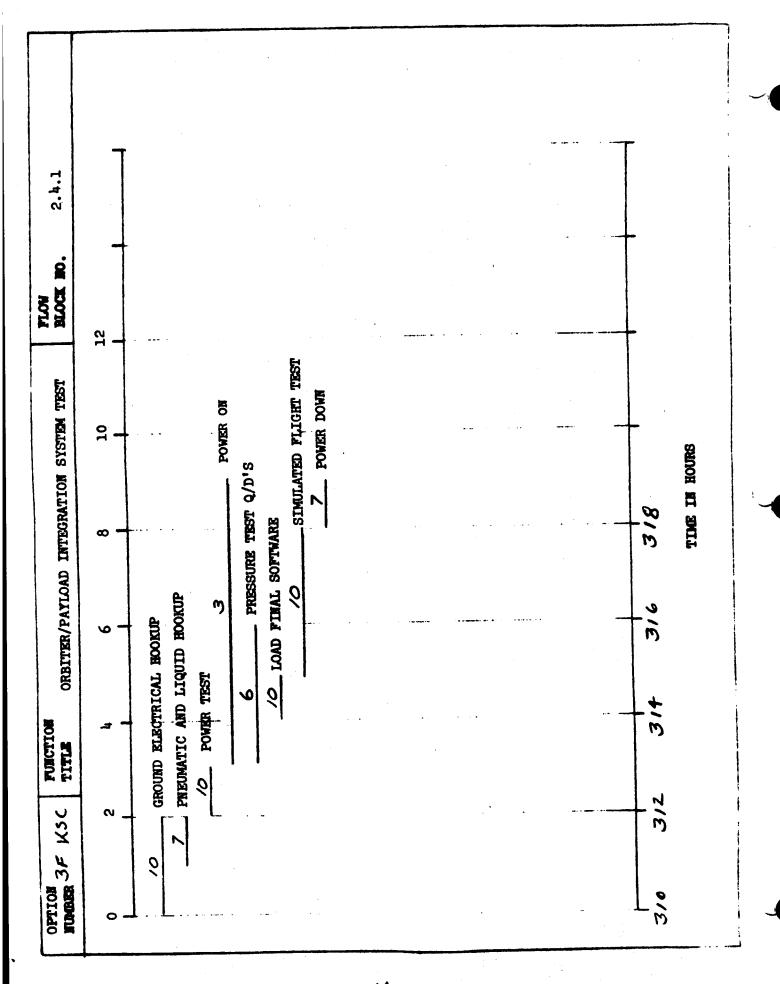
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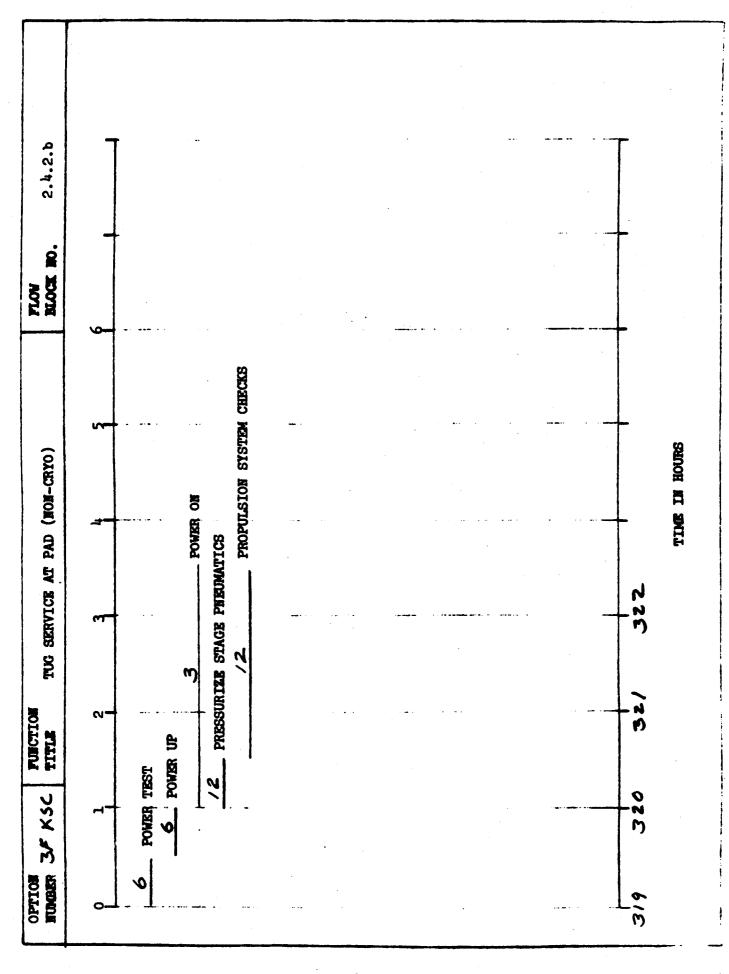
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# ON PAD VERSUS OFF PAD INSTALLATION (ACTION ITEM 139)

## MDAC Approach

Tug/Shuttle mating is currently baselined to occur at the Shuttle maintenance and checkout facility 144 hours prior to launch. After installation has been completed, however, the Tug is essentially inaccessible until, after orbiter erection and mating with the external tank, the Shuttle is transported to the launch pad 88 hours later. If, however, the Tug/Shuttle mating is performed at the launch pad, the Tug turnaround schedule can be shortened by 11 shifts. Compression of Tug turnaround has no effect on ground crew size which is primarily dependent on annual launch rates, however, the active fleet size can be reduced as the turnaround time is shortened. If the Tug production fleet size can be reduced (affective substantial savings), on-pad installation is highly desirable.

## MDAC Position

On-pad installation is highly desirable for Tug options 1 and 2 since production fleet size can be reduced by one Tug from 10 to 9 and 9 to 8 respectively.

# Rationale

The Tug production fleet size is based on equal usage of each Tug and the number of Tugs required during the last program year. Additionally during the last program year, for each Tug option one Tug es expended during the middle of the year which has the effect of reducing the flight capability of one Tug by 50%.

#### Figure 1 illustrates

- a) Tug active fleet size requirements for MCF and on pad installation versus annual launch rate.
- b) the launch rate spectrum for each Tug option
- c) identification of launch rate and required number of Tugs during the last program year for each Tug option.

Table 1 indicates launch rate and number of Tugs required during the last program year for each Tug option.

TUG OPTION	LAUNCH RATE	NO. OF TUGS
1	20	3
2	35	4
31	36	4
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By comparing Table 1 with Figure 1, it can be seen that for options 1 and 2, during the last program year, the active fleet and therefore the production fleet size can be reduced by one Tug.

The production fleet size for Tug Option 3 is however not sensitive to a turnaround compression of 11 shifts and the time and location of Tug/Shuttle mating has no effect on the number of production Tugs required to satisfy program needs.

# Impact

In addition to eliminating the requirement for on Tug in Options 1 and 2 (and the accompanying cost savings) additional substantial savings can be accomplished if installation occurs at the launch pad by eliminating the requirement for Tug/Shuttle GSE at the MCF. (Refer to Tug/Shuttle Demate and Safing Area versus Shuttle MCF.)

# ON-PAD VERSUS MCF INSTALLATION IMPACT ON FLEET SIZE

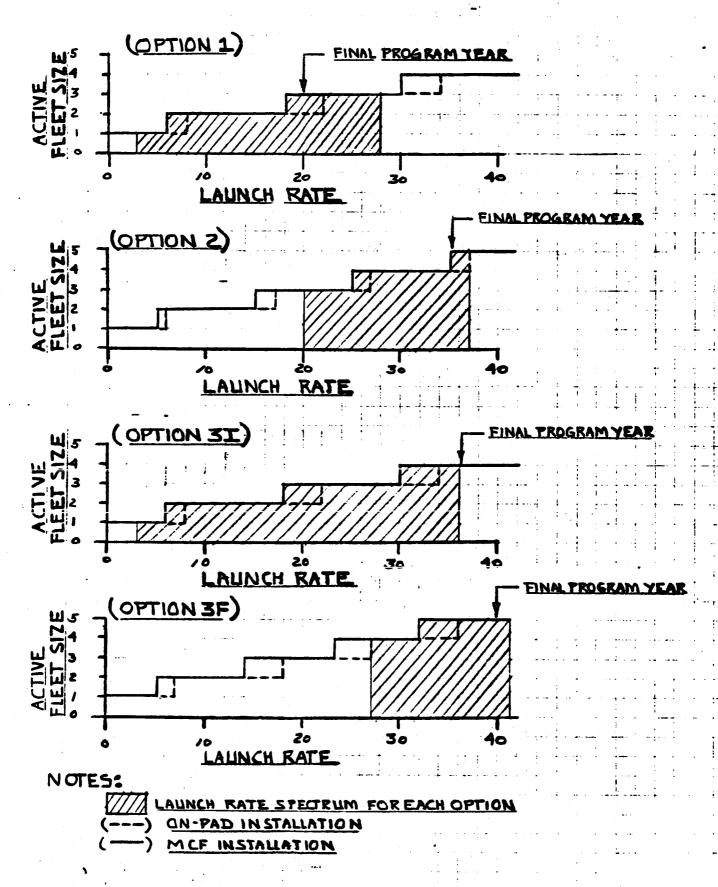


FIGURE 1

# TUG/SHUTTLE DEMATE AT SAFING AREA

# VERSUS SHUTTLE MCF

# (ACTION ITEM 98)

# MDAC Approach

Review of the functional timelines (3.2.3 versus 3.2.2) indicates that the Tug vehicle can realize a seven hour savings by removal at the safing area versus the Shuttle MCF.

# MDAC Position

Recover returning payload at safing area if payload/Shuttle integrations occurs at the launch pad instead of at the Shuttle maintenance and checkout facility.

# Rationale

If payload/Shuttle integration occurs at the launch pad a substantial savings in Shuttle/Tug GSE can be affected since

- 1) Shuttle/Tug integration and checkout GSE is no longer required at the MCF and equivalent GSE located at the launch pad will be utilized for on pad installation and post installation checks.
- 2) Shuttle/Tug demate GSE is no longer required at the MCF and Shuttle provided demate GSE at the safing area will be utilized.

Recovery at the Safing Area is no more or less complex, requires no more or less equipment, and requires no more or less men than recovery at the Shuttle MCF.

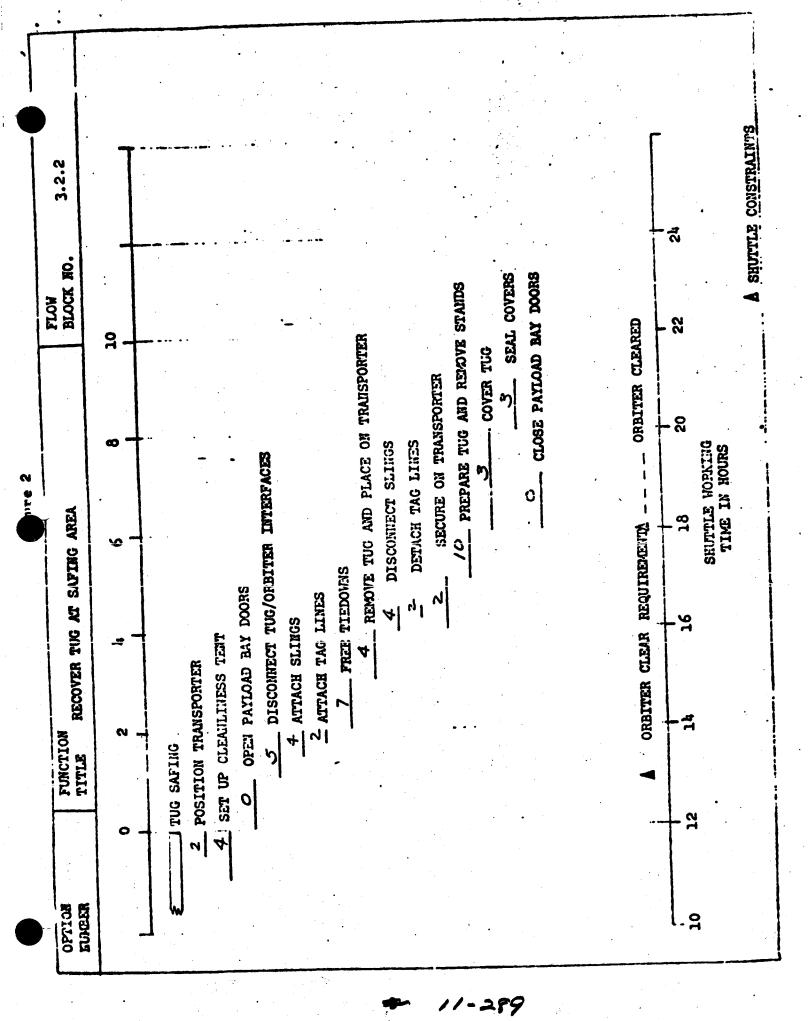
Reduction of Tug turnaround time by seven hours if Tug/Shuttle demate is accomplished at the Safing Area has no effect on the Tug program active fleet size or ground crew size. Since neither active fleet nor ground crew size is affected, the seven hours saved provides program planners with a seven hour pad with which to account for potential variances in the actual ground operations task times.

# Impacts

The Shuttle ground flow will require change to show this approach, however, since the Shuttle is providing for the capability (reference data package, page 50, paragraph B.2) there will be no inpacts to the Shuttle program or planned facilities.

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# 11.3.8 Manning Requirements

Total manpower requirements and skill mix as ETR and WTR are shown in Figure 11.3.8-1 through 11.3.8-4. The year to year variation in manpower is directly a function of the number of tugs flown in the mission model. The effect of a 2 year IOC delay is presented in Figure 11.3.8-5 through 11.3.8-8. Clearly this shortens the operational lifetime and reduces the total manpower expenditure. However, on a year to year basis there is no measureable effect.

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## 11.4 Logistics

The MDAC Space Tug Logistics Concept incorporates the Spares, Transportation and Handling, Training and Inventory Control and Warehousing functions.

## Spares

The maintainability analyses have addressed unscheduled maintenance in terms of spares requirements. This applies risk of failure analysis methods to prediction of spares requirements and maintenance manhours. The results of the analyses are summarized herein. It will be noted that several candidate configurations have the same predicted performance although there are differences in subsystem equipment. This results from several considerations. These include the gross state of descriptions that do not permit differentiation in parts counts or complexity of some components; all engines are considered to require the same unscheduled maintenance although there are differences in scheduled maintenance; and rounding off at a reasonable decimal value. All predictions were made by the same methods, thus assuring that the data presents the proper range of relative performance for purposes of preferential evaluation and ranking with regard to unscheduled maintenance.

Spare parts costs estimates were introduced into the cost model in terms of initial spares and depot maintenance, measured in terms of equivalent units of production subsystem hardware costs. The initial spares support repair of any failure present in a returning Tug for the first five flights. The estimates for subsystems assumed at least one of each replaceable item plus several additional parts for those items having a high failure risk and a long flow for depot overhaul. The initial stock is a function of flight frequency, depot flow time and desired probability of sufficient stock for any contingency. Depot maintenance costs are based on failure rate, estimated repair level (percent of component replaced) and percent of part cost to handle the cost of the repair cycle. An example of the method of calculation is provided in Appendix C.

# Transportation and Handling

This function considers the following areas of hardware movement:

- o Intrafacility operations at MDAC during manufacturing and refurbishment
- o Delivery of new Tugs to KSC and WTR
- o Rotable spares between launch sites and factory/depot area
- o Switching of individual Tugs between KSC and WTR
- o Intrafacility operations at KSC and WTR
- o KSC/WTR to and from Shuttle alternate landing site

The primary mode of transportation between MDAC and KSC/WTR will be by "Guppy" type aircraft when delivering new Tugs or when switching operational Tugs between KSC and WTR. Movement of Tug hardware (other than a complete Tug) will be accomplished via appropriate land and air modes as dictated by specific program requirements.

The selection of preservation methods, packaging levels, and protective handling shall be based on analysis of natural and induced environments to which the hardware will be subjected during its life cycle. Major emphasis shall be placed on minimizing damage from environmental hazards encountered during storage, handling and transportation. Special attention shall be given to parts procedures to insure that program critical hardware items are given preferential treatment throughout the manufacturing and logistics pipeline. Selection of preservation methods, packaging design, and level of protection shall provide a reasonable balance between cost and performance.

# Training

The training concept for the Tug Program is based on the premise that training will be required for all ground personnel (customer and contractor) and that personnel assigned to the Tug Program will already be skilled in their respective specialties; therefore, training requirements will be limited to the adaptation of their respective skills to Tug hardware and ground operations.

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Training will be conducted at the manufacturer's location and at KSC and WTR. There will be no requirement for simulators and dedicated training equipment. Test and flight hardware, augmented by audio/visual aids will be used. No special training facilities requirements are planned.

# Inventory Control and Warehousing

The material control function includes the receiving, shipping, issue, repair, inventory control and storage of spares, repair parts, and special test equipment (Contractor Furnished Equipment [CFE] and Government Furnished Equipment [GFE]) located at either the MDAC manufacturing facility or at the KSC/WTR launch sites. The MDAC concept considers the contractor and user's responsibilities from acquisition through the operational phase for property control and accountability of CFE and GFE being utilized to support the program. The contractor shall be responsible for controlling stock levels, issues, and maintaining inventory and property records of all material. The contractor shall maintain such records on GFE for the purpose of receipt control by requisition number and contract number. The contractor shall perform follow-up action in accordance with customer requirements. GFE spare end items furnished for the Contractor's Program shall not be co-mingled with GFE furnished for production installation. Progressively, usage data shall be compiled during the Contractor Support Program for systematic and timely support review to determine future procurement and stock replenishment. Accurate reporting of transactions and end use of hardware is the most important aspect of usage data.

CFE and GFE shall be stored under bonded warehouse concept, utilizing good housekeeping practices. Special emphasis is placed on control, security, and protection of material. Items furnished for support of this program shall not be co-mingled in storage with items of any other program, contract, or project. Items shall be stored in an arrangement that will facilitate stock control and inventory. The Armed Service Procurement Regulations (ASPR) and NASA Procurement Regulations contain the basic requirements for management and control of GFE in possession of a contractor. MDAC will handle CFE in the same manner prescribed for GFE and will assure that its subcontractors handle GFE on this program in accordance with the aforementioned government requirements.

MDAC, together with NASA/DOD will schedule two transition conferences; a planning conference and a final conference. At these conferences, the NASA/DOD and MDAC will review and evaluate the experience encountered throughout the Contractor Support Program, determine and initiate action to satisfy any deficiencies, and provide for an orderly transfer of assets to the government or operational contractor.

# 11.4.1 Spares

The spares planning analysis has developed a spares list to level 8 and a subsystem overhaul cost. The detail data are presented in Appendix C along with a description of the calculation methods used. The Tug maintainability analysis process is illustrated in Figure 11.4-1.

The spares planning data are primarily directed at developing a viable life cycle cost prediction. The list of potential spares was developed for two levels. The subsystems were analyzed to establish a repair policy that would be possible with the expected support equipment and test facilities. The repair policy provided a list of line replaceable units (LRUs) for Tug repair and refurbishment. These LRUs were in turn subdivided into subassemblies to provide a parts list to level 8. Reliability failure rates were allocated to the subassembly level and component and subassembly expected failures were calculated using flight time plus expected preflight ground operation time. An additional anomaly multiplication factor was applied to represent the number of items that may need to be changed or adjusted for each failure that actually occurs in a completely checked out, flight ready, system.

The expected failures value provided the basis for calculating spares and overhaul support. Poisson tables were used to determine quantities of initial and operational spares. Initial spares were selected in a quantity to provide an 0.90 probability of no LRU stock depletion for 5 flights. Operational spares were selected to assure at least one subassembly for repair of the LRU and additional quantitites as required to assure an 0.995 probability of sufficient stock to repair and refurbish LRUs with a level II maintenance flow rate based on 5 flights.

Depot spares estimates are based on equivalent subsystems required as a bottom up prediction, whose individual item depot costs are based on a 30% refurbishment cost for the expected failures for the total number of Tug missions.

The mathematics for the calculations are shown in Appendix C.

Figure 11.4. Tug Maintainability (M) Analysis Process

### 11.4.2 Training

Introduction. A comprehensive training program on the Tug subsystem and its associated support equipment will be provided to assure the availability of trained and qualified personnel required to produce, assemble, check out and deliver the tug and its associated support equipment and to support the test and operational flights.

During the Saturn S-IVB and OWS programs, MDAC participated in a comprehensive task-oriented classroom training program; making maximum use of engineering mockup, models, and simulation devices to develop and maintain personnel skills. Each course was tailored to meet specific NASA requirements and stressed man-rating and safety. These programs proved extremely successful as evidenced by these programs' achievements. The same policies and criteria will be utilized in the development of the Tug training program.

Training services for NASA, DOD & MDAC employes (technicians, engineers, inspectors, test flight personnel, etc.) will be provided by a centralized training group. This group will be staffed with experienced system training instructors organized and managed to meet NASA, DOD and contractor employe training requirements. These instructors participate in the development of training requirements, development of System Training Plan, and conduct training.

Objectives. The objectives of the Tug Training Program are:

(1) Identify and develop training requirements for courses in a timely manner to permit the orderly development and implementation of training; (2) Develop and implement training courses to ensure the availability of qualified personnel and skills required for the performance of assigned tasks; (3) Provide quantitative and qualitative needs for trained personnel that satisfy program

schedule requirements; and (4) Provide training services for customer and contractor personnel in support of their Tug system requirements.

Approach. Training services for NASA, DOD, MDAC employes (technicians, inspectors, test engineers, etc.) and flight support personnel shall be provided by a centralized training function. Cost control objectives shall be achieved by use of innovative training concepts developed for otherNASA and military training programs as follows:

- Centralized training management permitting instructor participation during the Training Requirements Analysis. Development of the Training Plan and the dual utilization of instructor for the conduct of both customer and employe training programs, being responsive to schedule requirements of both.
- Making maximum use of engineering development mockups, models and test and flight articles for training; thus eliminating the development and production costs of special training devices.
- O Identify the appropriate Audio Visual Media for application to classroom, OJT, and follow-up training as the system is developed.
- e Maintain a current catalog of Employe Training courses, complete with schedules, permitting the customer to participate as desired.

Program quality, quality of personnel, and cost objectives will be achieved by the implementation of these concepts. The planning and control function

is a key element for the smooth integration of NASA, DOD and MDAC Tug System Training Requirements

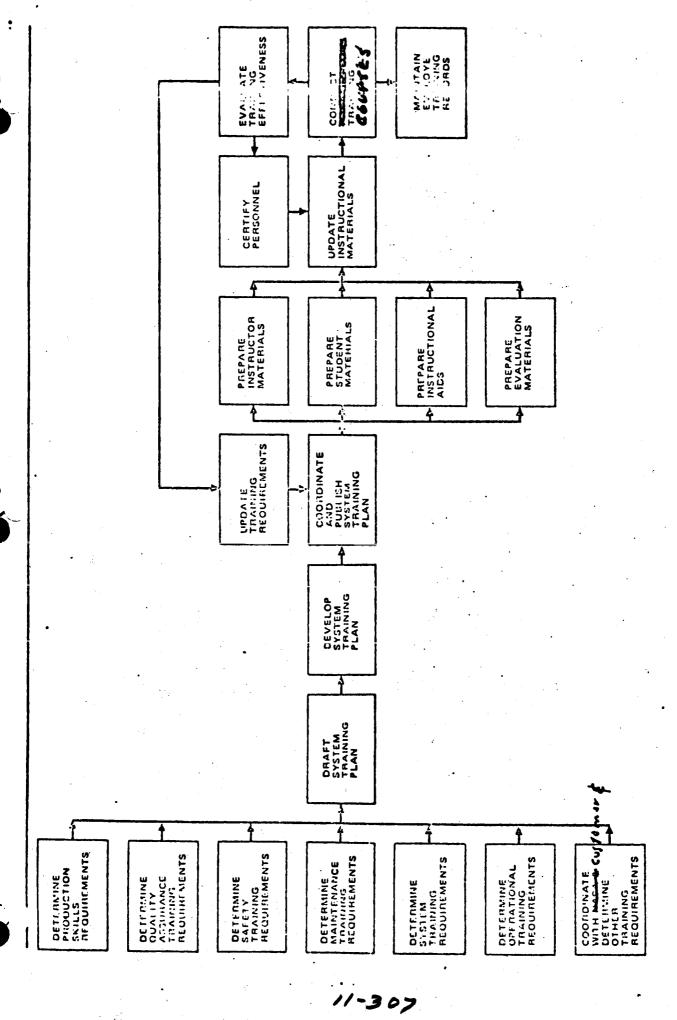
Training Requirements. Training Requirements Analysis for customer and MDAC personnel will be concurrent with the Design, Development and Production Planning. The analysis encompasses all areas of job/tasks function, i.e.,

production skills, quality assurance, test engineers, inspectors, etc., and is conducted in the following steps; population group identification, job/task definition, and the identification of technical material required for use by each population group. The analysis determines the requirements for both class-room and other types of instruction for personnel. All MDAC training records will be processed and maintained. Figure 11.4.2-1 illustrates the interrelation-ships, identifies the products and services provided, and the sequence of development and implementation. Special training requirements imposed by the customer are are developed, scheduled and conducted in the same manner as for MDAC personnel. Table 11.4.2-1 lists Tug training categories that are applicable for NASA and DOD personnel.

Table 11.4.2-1
NASA/DOD Training Courses

Type of Course	Description	Population Groups
Briefings	Introduction to the Tug program to include ground equipment. Serves as an introduction to individual systems briefings	
	and more detailed instruction.	management personnel & program planners
Familiarization	Introduction to the Tug program including ground equipment identification and description of subsystems, major units and functions.	Technical super- vision & flight personnel
Subsystems, Design	Detail analysis of design requirements, functional and operational. Parameter of subsystem and its supporting ground equipment.	Project System Engineering, Ops engineering, launch support

MDAC training requirements analyses are concurrent with the development of Systems Requirements and Support Requirements.



Training Products and Services Figure 11.4.2-1.

Student population groups are identified, job/task definitions developed, skill levels determined to accomplish task and the identification of technical materials required for use of each population group. The analysis determines the requirements for both classroom and other methods of instruction for MDAC personnel. Table 11.4.2-2 identifies employee population groups requiring training and a brief description of the type of instructions provided.

Table 11.4.2-2

Development & Production Training Programs/Courses

Employe Population Groups	Description
Safety	Identification of hazards and notential hazards to personnel and equipment, and methods of accident prevention.
Inspection and non-destructive testing	Work-oriented instruction on techniques and procedures on testing, inspection, and operation of specialized equipment for quality assurance personnel.
System and support equipment	All levels of instruction describing theory and function of operational end items, systems, subsystems, and support equipment.
Transportation and handling	Describe operation of equipmentboth static and mobileused to handle, transport or position hardware.
Maintenance	Detailed task-oriented instruction in maintenance, servicing, overhaul, and repair of equipment.
Material processes	Skill development in critical menufacturing process, i.e., metals, chemicals, bending, compounds, welding, etc.
Assembly processes	Skill development in critical manufacturing process, i.e., metals, chemicals, bending, compounds, welding, etc.
Test equipment operation	Task-oriented instruction on operation and application of standard and special test equipment.

The result of the training requirements analysis is documented and included in the training plan. The updating of the requirements is continuous and incorporated into each revision of the Training Plan.

Tug System Training Plan. Development of a Tug System Training Plan shall be initiated at ATP and be concurrent with the Training Requirements Analysis. The Training Requirements Analysis is the basis for identifying courses to be conducted for NASA, DOD, and MDAC employes. The plan identifies methods and procedures for each course, course objectives, and identifies equipment required to support the course; it includes course outlines, descriptions, manpower requirements, evaluation criteria and contains a schedule for each course identifying the location of presentation so customer personnel may participate, as desired. This curriculum includes general purpose courses to provide personnel with brief general descriptions and functions of the Tug system, plus job-oriented courses for student population groups identified in the Training Requirements Analysis. The plan shall identify any special courses for customer personnel required for a smooth transition from DDT&E to Operations. The training plan is a working document for training implementation and becomes the framework for annual planning of training operations. Adjustments are made to the plan as program requirements are altered, and an annual updated submittal shall be -made through the first manned orbital flight.

Production Skills Training. Processes involving vocational skills training are identified in the Detail Process Standards (DPS) or Detail Process Instructions (DPI) prepared by Material Methods and Research Engineering (MM&RE), and training is conducted in accordance with these instructions. Upon completion

of vocational skills courses, students are required to demonstrate skill proficiency by manual and written examinations, and are certified as required by QA. Apprenticeship and/or learner programs, where applicable, are developed, conducted and administered by Training in accordance with Federal and State regulations.

Quality Assurance Training. Courses designed for Quality Assurance personnel stress the inspection techniques and quality requirements in addition to manipulative or manual skills. Quality control is an integral part of all skills training programs. The contribution of each individual's work to the success of the program is constantly emphasized.

Safety Training. Personnel and system safety is stressed in all training courses. The Safety Department and/or the Safety Manual may indicate areas for special concentration. These special safety training programs are established and conducted for identified employes or departments after course approval by the Safety Department.

Technical Training. Technical training is accomplished by various methods, conducted by the training organization, performed by experts from the operating department involved (with guidance and assistance from the Training Department), or programmed with self-taught instructional media. Whatever methods used are coordinated and approved by the Training Department prior to the conducting of the course.

Technical orientation is initiated early in the program to orient newly assigned personnel on the Tug Program, provides a general description of the Tug system, system function, and Shuttle interface information, and is planned to be approximately four classroom hours. The technical content will be maintained at a level consistent with the instructional objective of

providing management, and newly assigned personnel, with a brief but comprehensive overview of the Tug Program .

Familiarization training courses are developed for presentation to Engineering, Technical, Manufacturing, Checkout, and Quality Assurance personnel as soon as desigh concepts are established to provide thorough familiarity with all aspects of the Tug system, supporting equipment and operation. The technical content will be maintained at a level consistent with the instructional objective of providing technical personnel with a working knowledge of the Tug and its supporting equipment, and is planned for approximately eighteen classroom hours.

The identification and depth of maintenance training courses result from Support Requirements Analysis (SRA). The results of the SRA will culminate in the identification of maintenance training requirements, and courses will be designed to support all levels of maintenance. Instruction in detailed system operation, trouble-shooting and repair techniques provide the skills required to meet scheduled turn-around requirements, cost, and loading effect on equipment and facilities. Course outlines and descriptions will be developed and documented in the Training Plan.

MDAC personnel involved in test flight operations are provided detailed instructions on the Tug system and its support equipment in terms of trouble-shooting, on-line repair, test and launch operations. The level of instruction provided is identified in the Training Requirements Analysis and documented in the training plan. Special course are developed and documented for technical personnel, and the implementation is consistent with the program schedule.

NASA, DOD and Launch contractor personnel are invited to attend these courses to partially fulfill the operational training requirement for transition to the operational phase.

The initial cadre of personnel for the operational phase will participate in test flight training, test flight launches, and be prepared to support the operational launches. Additional launch teams assigned to meet the projected launch schedule will receive the same instruction as flight test personnel, and all crews will require refresher training periodically to maintain their launch capability and proficiency.

Maximum use of engineering mockups, models, etc. shall
be made to enhance the instructional program for the development and maintenance
of personal skills required to assemble, check out, test and launch the Tug
system. Instructional devices are production hardware, wherever practical, and
rejected parts, components or test items are utilized when they do not detract
from the training objectives.

Tools and machines required for vocational training are the same as used in production areas, and applicable training will be accomplished on equipment in the production area, where possible. Documentation of vocational training courses will be accomplished in accordance with established standards.

Instructional Documentation. The Tug system documentation is utilized for task-oriented instructions when it is determined to be suitable for instructional purposes. When system documentation is not suitable or available for instruction, special training documentation shall be developed, such as operational and functional diagrams, descriptions and interface information.

The preparation of Tug training manuals is initiated at system PDR, making maximum use for existing documentation, and includes system and subsystem descriptions, functional diagrams and visuals to enhance the learning process. The manuals are prepared, published and used to fulfill the training require-

ments of operational training and are turned over to the customer at the completion of test flight operations.

Instructional Media. Instructional media used varies according to the subject and training objectives. Basic technique used is oral presentation, demonstration, application, examination, review and/or critique. Instruction is supported by video tape, overhead transparencies, slides and movies.

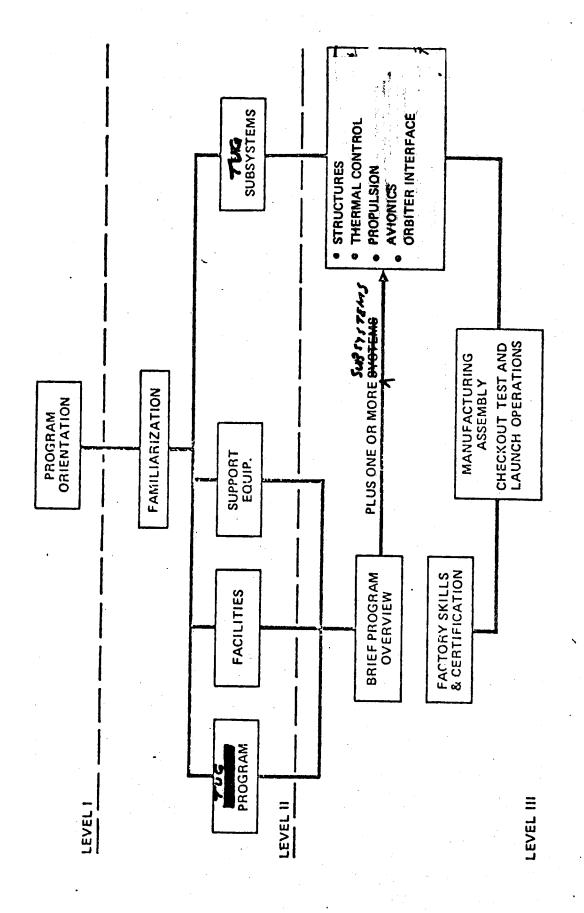
As a supplement to the tri-level Tug classroom training,

video tape presentations and demonstrations will be developed for tasks and subjects where such supplement is indicated by the training requirements analysis. Video tape is particularly effective as an instructional aid in bringing the production areas into the classroom for vocational skills training.

Video casettes, chosen for ease of operation consistent with high image quality, will be produced by MDAC personnel experienced in telecommunications production on the Safeguard and Skylab programs. These video casettes can be easily updated to include program or design changes, and will provide readily accessible refresher material for NASA, DOD and launch contractor personnel after initial training.

Training Program Implementation. The basic method of instruction' shall be the traditional standup technique of classroom instruction using charts, transparencies, chalkboard, etc., and augmented by special audio-visual techniques when they enhance the training or are cost-effective.

Tri-Level Training Concept. A tri-level approach is planned for implementing the Tug training program. This approach enables each employe to receive only that instruction relevant to his job assignment. This approach reduces the number of student classroom hours by not subjecting him to "nice-to-know" but irrelevant information. MDAC shall conduct all courses using the tri-level approach. Figure 11.4.2-2 illustrates this concept, and a brief description of each level of presentation is provided in the following paragraphs.



is re 11.4.2-2. Training Levels

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Level One - Orientation. The orientation courses will introduce the Shuttle Program, the Tug vehicle and its associated support equipment to all program personnel as they are assigned, and provide them with general descriptions and functions of the systems to be utilized on the Tug program. Technical content of the course will be maintained at a level consistent with the objective of providing management, planners, and newly assigned personnel with a comprehensive but brief overview of the Tug program.

Level Two - Familiarization. Familiarization courses provide a brief overview of the Shuttle program, and expand upon the Tug system, system support equipment, manufacturing and checkout operations, culminating in factory checkout, assembly and test flight operations. These courses are the basis upon which specialized training for particular task areas are founded.

Level Three - Specialized. These courses will be designed to provide a brief overview of the Tug Program and detailed theory, operations, and maintenance functions associated with specialized tasks on the Tug vehicle. support equipment, assembly, test and launch.

Summary. MDAC is responsive to the Tug Program requirements by providing a training staff of experienced training specialists to participate in the definition of Tug system training requirements, developing a training plan, and conducting training. The preparation and conduction of training shall be time-phased to provide qualified personnel, economically managed to control program cost, and flexible enough to meet all program requirements.

A representative manpower build-up is shown in Figure 11.4.2-3AND 11.4.2-4

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TRAMING BUILD-UP

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### 11.4.3 Transportation and Handling Introduction

The Spare Tug, its subsystems assemblies and components will be moved a considerable number of times during their program life by a variety of transportation and handling vehicles and equipment. During these movements, the Tug vehicles/equipments are subjected to stresses and loads which may vary from those experienced in a mission environment. The Tug design criteria will be based on flight loads; therefore the transportation and handling loads must be predicted during design and, where necessary, reduced to assure that structural damage does not occur during Tug transportation and after ground operations. The methods and procedure necessary for protection of the Tug hardware elements during vehicle assembly, testing, transportation and storage are developed as a result of the transportability/transportation analyses.

The selection of preservation methods, packaging levels, and protective handling will be based on analysis of natural and induced environments to which the hardware will be subjected during its life cycle. Najor emphasis shall be placed on minimizing damage from environmental hazards encountered during storage, handling and transportation. Special attention shall be given to parts protection procedures NDAC will follow to ensure that program critical hardware items are given, preferential treatment throughout the manufacturing and logistics pipeline.

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As a matter of policy, transportation and handling planning will incorporate the following guidelines and assumptions:

- a. Use of existing, rather than design of new transportation and handling equipment, where practical.
- b. Early identification of any Tug Program peculiar transportability constraints.
- c. Maximum utilization of state-of-the-art packaging materials, methods, and designs, where practical.
- d. Special protective measures for Program critical hardware.
- e. Implementation of integrated packaging, handling, and transportation functions outlined in MSFC-STD-343 to the maximum extent possible within cost effective guidetines.
- f. Preferential consideration of air transportation, but use of other modes where more effective or practical.
- g. Appropriate safety provisions for dangerous or hazardous

### Transportability

Some of the Tug Program items (assemblies, subassemblies, GSE and spares may be oversize environmental sensitive or hazardous relevant to normal transportation modes. Therefore,

a transportability analyses shall be performed to ensure that

the Tug vehicle hardware, GSE and their shipping containers/fixtures are designed for efficient transportation. Transportability analyses are provided to define hardware constraints required to select transport and handling equipment and primary and alternate modes of transportation. The basic tasks that are accomplished in the transportability engineering

### Process are as follows:

- a. Identify potential transportability problem areas and define the nature of the constraints (oversize, environmentally sensitive or dangerous).
- b. Perform transportability analyses to determine transportation impact on hardware design and preferred methods for transporting problem items.

- c. Prepare transportability reports for problem areas. The reports will provide the following data:
  - Detailed characteristics of problem items (size, weight, C.G. environmental sensitivity, hazardous, etc.)
  - 2. Special packaging, handling and transportation requirements.
  - 3. Handling, loading and tie-down methods and configuration for proposed transportation methods.
- d. Develop transportation data for special items (as required).
- e. Investigate capabilities and limitations of available equipment and service of the candidate modes of transportation at origin and destination.
- f. Evaluate transport limitations at manufacturing, assembly, and test sites.
- g. Investigate existing handling and transportation equipment inventories for possible use on the Tug Program,
- h. Provide handling and transportation procedures and instructions defining methods of loading, off-loading, securing and handling problem items for shipment.
- i. Provide transportability inputs to system and equipment specifications.
- j. Define the natural and induced environments that hardware will encounter.
- k. Develop transportation and storage requirements for hardware in logistics pipeline.
- 1. Develop requirements criteria for the design of special transportation equipment.
- m. Conduct transportation tests for oversize items container designs, as required.
- n. Provide transportability engineering support to program for shipment and receipt of test items and mockups.
- o. Establish interface with Design Engineering, early in Program, to minimize transportability constraints.

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### Transportation and Handling

An overall transportation plan, including packaging, handling, transportation and storage, shall be developed and implemented as a part of the total system approach for the movement and storage of Tug hardware. The purpose of the plan is as follows:

- a. Establish an optimum system for moving materiel, defining the system in such detail that the impact of individual elements on total system cost and performance can be analyzed.
- b. Provide technical requirements and administrative procedures for implementing safe and timely movement of materiel.
- c. Provide management with sufficient visibility of the packaging, handling and transportation system to effectively control and manage its implementation.

Transportation tasks which must be accomplished for developing and implementing an effective plan are as follows:

- a. Perform feasibility and cost trace-off studies in the areas of packaging, cargo handling, transportation and storage to develop the most cost-effective system for the movement of Tug hardware.
- b. Integrate transportability data into transportation planning activities.
- c. Provide reute surveys for oversize items.
- d. Identify the hardware snipments by destination and volume for maximum consolidation.
- e. Establish transportation flow patterns for the different hardware categories.
- f. Determine most feasible and economical methods for transporting the various categories of material in consonance with program schedules.
- g. Identify the shipping documentation used during shipment.
- n. Identify unique requirements for special transportation equipment and services for each shipment.
- i. Release transportability reports recommending preferred modes for potential problem items.

- j. Identify functional responsibilities for implementing the transportation plan.
- k. Establish traffic management procedures for obtaining the proper handling and transportion equipment.
- 1. Provide procedures for obtaining route clearances and overweight/dimensional permits.
- m. Establish traffic management procedures for controlling the movement of nardware in transit.
- n. Establish procedures for interfacing and coordinating with customer transportation agencies.
- o. Define the Department of Transportation, NASA, DOD and other federal. state and local government regulations governing the Tug. packaging, transportation and storage activities.
- p. Manage and coordinate all movements of heavy, bulky Tug components with other agencies and supervise vehicle loading/offloading activities.

### Preservation, Packaging and Packing.

A systems approach shall be implemented for performing the activities associated with the protection of Tug Vehicle hardware, spares, GSE, tooling, and test equipment during movement and storage. Centralized control shall be provided to eliminate duplication of tasks and reduce distribution costs. Preservation methods, packaging design, and level of protection will provide reasonable balance between cost and performance. A description of the tasks follow:

- a. Direct all activities necessary to develop and coordinate program preservation, packaging, and packing.
- b. Develop and design in-plant and intra-plant handling devices and containers.
- c. Develop and issue drawings for containers, tie-downs, loading and handling instructions, parts protection, and hazardous material.
- d. Prepare "Preparation for Delivery" sections of Specificat Control, Source Control, and Design Procurement drawings.
- e. Coordinate packaging, handling, and transportation matters with customer. //-3a 2

- f. Develop and maintain Packaging and Preservation sections of Transportation Plan for the Tug Program.
- g. Conduct training courses on packaging procedures for field station preservation and packaging personnel.
- h. Develop and issue material and process specifications.
- i. Interface with Maintainability and Maintenance Analysis for detailed preservation and packaging requirements.
- j. Prepare and release in-plant packaging and handling instructions.
- k. Monitor subcontractor and vendor packaging activities.
- 1. Coordinate packaging designs and instructions with engineering and operations personnel.
- m. Identify and provide special instructions for handling, shipment, and storage of program critical and hazardous hardware, such as rocket motors. Release Special Protection Items List (SPIL).
- n. Analyze environmental hazards encountered in handling, transporting, and storing hardware in logistics pipeline.
- o. Develop and design light-weight containers for flight hardware, fly-away kits, and test support equipment.
- p. Prepare a Storage Plan defining levels of protection for temporary and long term storage.
- q. Prepare and release Special Design Packaging drawings for these items presenting unusual transportation and handling problems.
- r. Initiate Packaging, Handling, and Transportation Record (PHTR) for program critical and high cost items.
- s. Release instructions for implementing NASA Zero Damages-on-Delivery (ZEOD) Program.
- t. Release special instructions for marking critical and dangerous materials.
- u. Develop packaging, mandling, and transportation records (PHTR) per MSFC-STD-343.

### Transportation Modes, Matrix and Cost Methodology

The two major modes of transportation planned for the Tug Program are (1) air and (2) truck. The air mode will employ Guppy aircraft to transport a complete tug and commercial airfreight or US Air Force Cargo aircraft to transport Tug hardware elements of lesser size than the complete tug. The air mode will be used primarily for long distance movement and the truck/transportation mode will be employed for short distance/local movement requirements. A transportation matrix showing the type of interfacility traffice is shown in Figure 11.4.3-5. The transportation cost methodology is shown in Figure 11.4.3-6 and 7.

Matrix
Transportation 1
2,5
רר פאנים אם

			<del></del>	<del></del>		<del></del>		i
	TEST SITES	REPAIRED/ REPLACEMENT LRUS			MAIN ENGINES, REPAIRED/ REPLACEMENT LRUS	REPAIRED/ REPLACEMENT LRUS	INTRAFACILITY HANDLING	•
	SUBCONTRACTORS AND SUPPLIERS	REPAIRABLE LRUs	REPAIRABLE LRUs	REPAIRABLE LRUS		INTRAFACILITY HANDLING	REPA I RABLE LRUS	
	GFE CONTRACTORS	MAIN ENGINES AND REPAIRABLE LRUS	MAIN ENGINES KICK STAGES & REPAIRABLE LRUS	MAIN ENGINES, KICK STAGES & REPAIRABLE LRUS	INTRAFACIL ITY HANDL ING		MAIN ENGINES AND REPAIRABLE LRUS	-
	NEW TUGS		OPERATIONAL TUGS	INTRAFACILITY HANDLING	MAIN ENGINES AND KICK STAGES	REPAIRED/ REPLACEMENT LRUs	HANDLING EQUIPMENT	
,	KSC	NEW TUGS	INTRAFACILETY HANDLING	OPERATIONAL TUGS	MAIN ENGINES AND KICK STAGES	REPAIRED/ REPLACEMENT LRUS	HANDING EQUIPMENT	-
	MDAC HUNTINGTON BCH	INTRAFACILITY	REPAIRABLE LRUS	REPAIRABLE LRUS	HAIN ENGINES AHD REPAIRED/ REPLACEMENT	REPAIRED/ REPLACEMENT LRUS	REPAIRABLE LRUs	
	FRO:4	MDAC HUNTINGTON BCH	KSC	WTR	GFE CONTRACTORS	SUBCONTRACTORS AND SUPPLIERS	TEST SITES	
	8			11-	325		•	٠.

### METHODOL COST **TRANSPORTATION**

PROGRAM OFTION ETR -FLEET SIZE:

TRAFFIC REQUIREMENT

INITIAL DELIVERIES

1 KSC TUG SMITCHED WITH 1 WTR TUG ONCE EACH YEAR

GUPPY AIRCRAFT ESTIMATED COST PER FLIGHT

LOS ALMITTOS MAVAL AIR STATION, CALIFORMIA TO KSC =\$25K (ONE WAY) AND \$50K (ROUND TRIP)

LOS ALAMITOS MAVAL AIR STATION, CALIFORMIA TO WTR = \$5K (ONE MAY) AND \$10K (ROUND TRIP)

WTR TO KSC =\$25K (ONE MAY) AND \$50K (ROUND TRIP)

CALCULATION

. INITIAL DELIVERIES TO KSC AT \$25K/TRIP INITIAL DELIVERIES TO WTR AT \$5K/TRIP KSC TUGS TRANSFERRED TO WIR AT \$25K/TRIP WTR TUGS TRANSFERRED TO KSC AT \$25K/TRIP

LRU TRANSPORTATION COSTS INCLUDED IN DEPOT MAINTENANCE COSTS NOTE:

TOTAL

INTRAFACILITY HANDLING COSTS INCLUDED IN FACTORY/DEPOT AND LAUNCH SITE OPERATING OVERHEAD

Figure 11.4.3-6

# ANSPORTATION COST METHODOLOGI

NPUT DATA - PROGRAM, OP710N 3F FLEET SIZE: 2 ETR - 8 WTR - L

TRAFFIC REQUIREMENT

INITIAL DELIVERIES

1 KSC TUG SWITCHED WITH 1 MTR TUG ONCE EACH YEAR

GUPPY AIRCRAFT ESTIMATED COST PER FLIGHT

LOS ALMAITOS MAVAL AIR STATION, CALIFORNIA TO KSC =\$25K (ONE MAY) AND \$50K (ROUND TRIP) LOS ALAHITOS MAVAL AIR STATIOM, CALIFORMIA TO WTR =\$5K (ONE MAY) AND \$10K (ROUND TRIP) WTR TO KSC =\$25K (ONE MAY) AND \$50K (RCUIID TRIP)

COST CALCULATION

S INITIAL DELIVERIES TO KSC AT \$25K/TRIP | INITIAL DELIVERIES TO WTR AT \$5K/TRIP

KSC TUGS TRANSFERRED TO WITR AT \$25K/TRIP WITR TUGS TRANSFERRED TO KSC AT \$25K/TRIP

2.00K 100K 100K

INTRAFACILITY HANDLING COSTS INCLUDED IN FACTORY/DEPOT AND LAUNCH SITE OPERATING OVERHEAD LEU TRANSPORTATION COSTS INCLUDED IN DEPOT MAINTENANCE COSTS

TOTAL

Figure 11.4.3-7

11-327

### 11.5 Facilities

This section describes the manufacturing and test operations and Tug processing facility requirements with cost data used in trades.

### 6.11.5.1 Manufacturing and Test

Manufacture and checkout of the Space Tug will be accomplished at the McDonnell Douglas Astronautics Company, Huntington Beach, California, facility.

The Huntington Beach facility was planned and designed from inception to provide fully integrated facility capabilities for space vehicles. Its buildings consist of engineering and administration offices, a Systems Integration Laboratory, Structural Test Laboratory, Space Simulation Laboratory, Production Test Laboratory, Manufacturing and Assembly Building, Insulation Building, Final Assembly and Checkout Building, and other service and support buildings.

Maximum utilization will be made of the existing MDAC and government owned facilities used on the Saturn SIVB Orbital Workshop and other programs in the development and production of the Space Tug. This will include but not be limited to such MDAC facilities as the existing machine shops, sheet metal shops, process shops, electrical/electronic fabrication and assembly, and supporting inspection and test laboratories.

A preliminary list of additional facility requirements identified at this time, for each of the configurations are shown in Table 11.5.1-1 along with ROM cost and procurement lead time estimates.

Production testing (and checkout) will be done at Huntington Beach in existing laboratories of the McDonnell Douglas Astronautics Company facilities. These laboratories, designed and used for space vehicles, will require little or no modification for use in the Space Tug Program.

Vehicle PTV tests will be conducted in test cell J4 of the AEDC facility at Tullahoma. Test cell J4 provides an altitude simulation capability lacking in the test facilities at Huntsville. Thermal tests of the vehicle will be accomplished in the NASA High Vacuum facility utilizing an existing scaled

## SPACE TUG STUDY ADDITIONAL MANUFACTURING FACILITIES

				ROM COST	
	DESCRIPTION		LEAD TIME	OPTION 1 & 3 C. 101 2	cul
તં	. AGEIIG OVEH 20 FT X 20 FT × 8 FT (325°F)		SHIMOW 9	30,000	\$ ·
N	AUTOCIAVE 16 FT DIA X 12 FT LONG (600°F		TO NOWINS	130,000	€f .
m	CHEM-MILL PACILITY 2 TANKS 20 FT X 20 FT	X 20 FT X 12 FT	10 MONTHS	500,000	
**	. ANODIZE FACILITY 20 FT X 20 FT X 10 FT TANKS	Sylve	4 MONTHS	200,000	-1,
'n	CLEAST ROOM/10 TON BRIDGE CRATE 5000 SQ FT	T (100,000 CLASS)	8 MONTHS	250,000	:
જં	6. ACOUSTIC PMISSION TEST EQUIPMENT (PATE)			150,000	
F.	7. ACOUSTIC EMISSION TEST EQUIPMENT (PATE)			75,000	, 1
				000,530,1	0
ထ	8. CURING OVER 16 FT X 16 FT X 8 FT (600°F)	•	6 MONTHS	000,03	0
•				1 025 000 1 000	1 6
7 7		<b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> → <b>H</b> →			)
		· · · · · · · · · · · · · · · · · · ·			
ari S		TEST FACILITIES			T.
•				IASA DOD	
તં`	, MDAC HUNTINGTON BEACH LABS				-
ci.	2. NASA HUNTSVILLE HIGH VACUUM FACILITY			_o_ 50°05	
m	3. AEDC TULLAHONA MARK 4 CHAMBER		H	1,250,000 -0-	•

down and instrumented tank that will fit the 15 foot diameter chamber. These government facilities are available at no cost or at a nominal fee depending on the using agency (see Table 11.5-1).

### 11.5.2 Operations Facilities

The requirement for Tug launch facilities at ETR eill be satisfied with constuction of one new building 11.5.2-1, by modification and refurbishment of existing buildings and by use of Orbiter facilities that can be expanded or adapted to include Tug service (Figure 11.5.2-2)

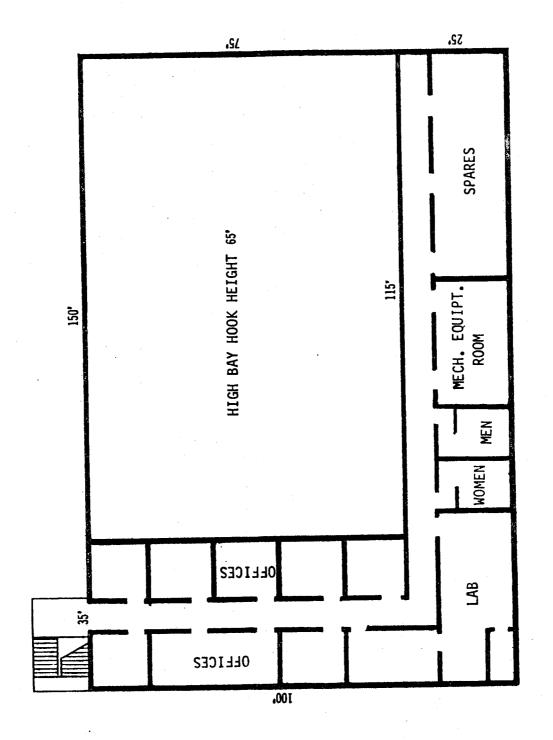
At WTR, construction of a new Payload Processing facility (Figure 11.5.2-3) together with use of programmed Shuttle facilities expanded to satisfy Tug needs will provide the support required.

### 11.5.3 Facility Costs

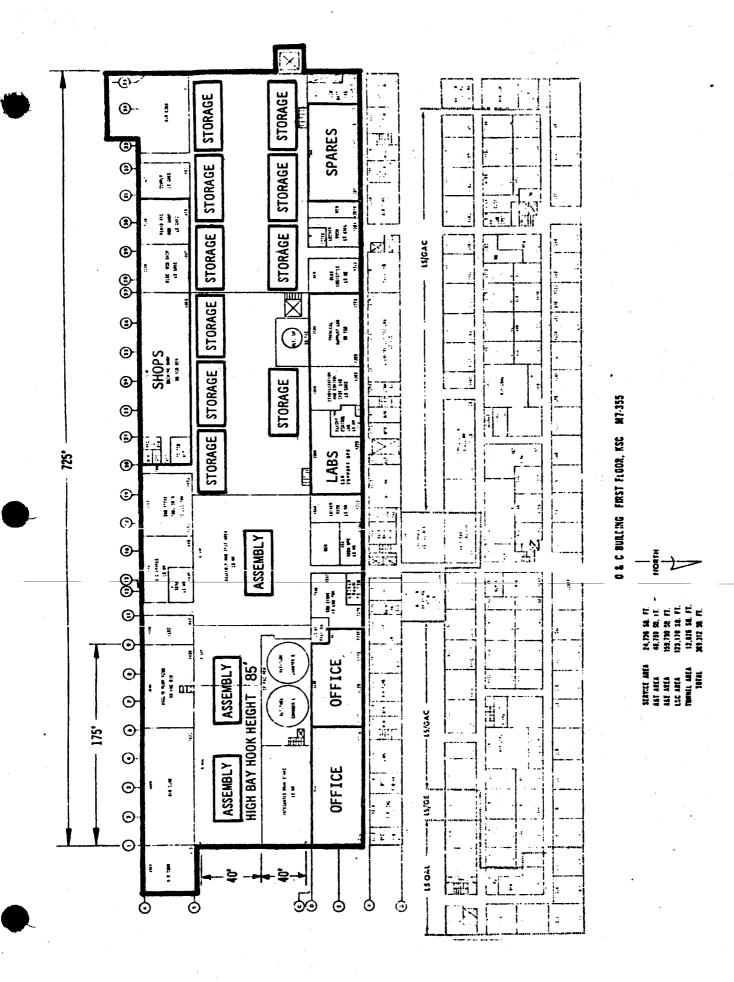
A tabulation of these facilities' status and cost is presented in Table 11.5.3-1 and in Facility Description sheets.

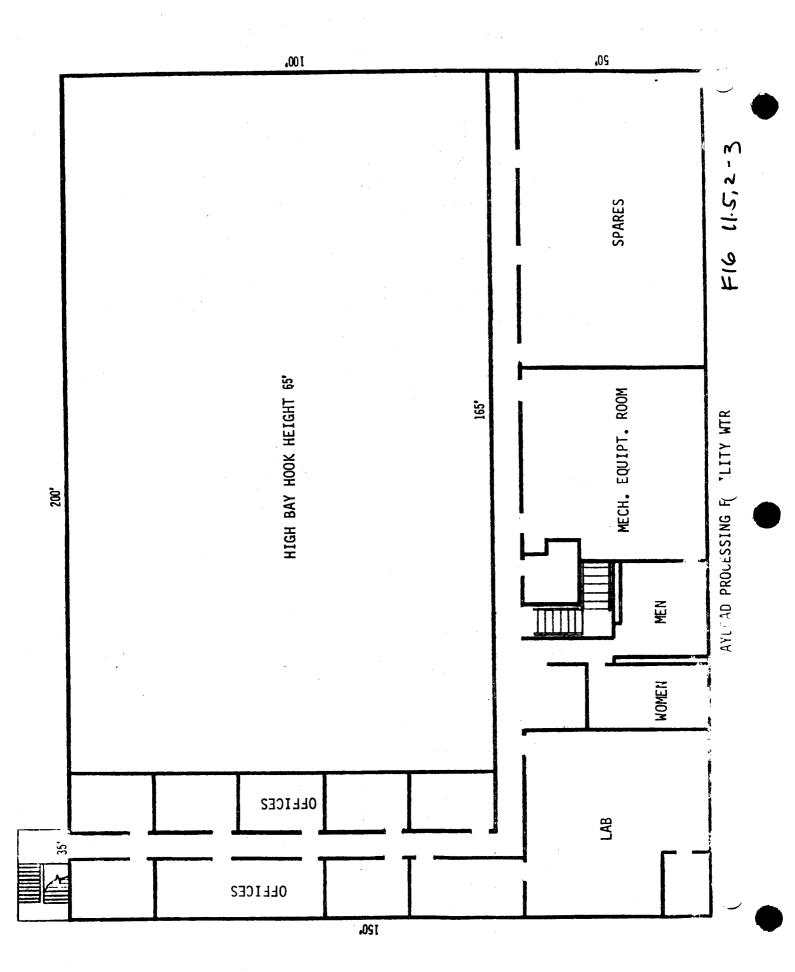
Table 11.5-1 OPERATIONAL FACILITIES SURMARY

N. T.	·	750,000	•	10,000		350,000		-0-	•	4		þ		10,000	1,120,000
KSC	500,000	0000	10,000		350,000		10,000		0-		-01		10,000		1,380,000
ORIGIN	Modified KSC Bldg M7-355	Mex	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	Modified Shuttle Facility	
FACILITY	Tug Processing Facility	Payload Processing Facility	Maintenance and CO Facility	Maintenance and CO Facility	Launch Service Structure	Launch Service Structure	Launch Control Center	Launch Control Center	Safty Facility	Safing Facility	Storable Propellant Facility	Storable Propellant Facility	Vertical Assembly Building	Vertical Assembly Building	



PAYLOAD PROCESSING FACILITY KSC





### Ground Support Equipment (GSE)

The results of the GSE task include the detailed definition of the GSE, quantities, price, development schedule, and GSE at each location for factory, Eastern Test Range (KSC) and Western Test Range (VAFB) which are required to support both MASA and DOD Tug missions. It also includes a definition of equipment that is Government Furnished Equipment (GFE) which is available from the Saturn and Delta program that is usable for Tug.

### Overall Study/Program Objectives

The overall study/program objectives which relate to the GSE and software tasks are to:

- (1) Low design, development, test and evaluation (DDT&E) for GSE and software for Space Tug capability.
- (2) Reasonable turnsround and checkout philosphy.
- (3) Flexible GSE to checkout many configurations of Tug/spacecraft.
- (4) Utilize GFE as much as possible to reduce overall cost and not degrade checkout.

### Methodology for Development of GSE and Software

The methodology for defining the GSE and software required for each option was defined as follows:

- (1) Utilize the functional flows to establish equipment locations where hardware is required.
- (2) Utilize vehicle hardware description to establish type of GSE required to checkout vehicle.
- (3) Utilize vehicle function list, schematic, and instrumentation list has established number of functions across vehicle/GSE interface and number of functions to be monitored.
- (4) Sized the GSE to percentage of existing GSE from similar programs Saturn, Delta, and Skylab programs, Developed GSE hardware descriptions. The costing personnel then took actual cost for GSE hardware descriptions.

- (5) Established a checkout philosophy similar to the Airline method of checkout using trend data from previous missions.
- (6) Defined all interfaces and equipment required to checkout their interfaces and developed hardware description for the GSE.
- (7) Developed factory, Tug Processing Facility, Payload Processing
  Facility, Orbiter Maintenance and Checkout, and launch pad checkout
  and GSE block diagrams. Developed AEDC and Integrated Avionics Test
  flows and block diagrams.
- (8) Developed schedules for development of GSE and software.
- (9) Developed software development and operation task flows.
- (10) Define all software programs required for checkout, maintenance, and support programs.
- (11) Software personnel sized each program defining number of words of memory required for each program. Multiply the memory words times a certain dollar rate establish the cost for development of that program. These programs were then compared to similar programs on the Delta program to establish confidence in our software numbers developed for this program. Sustaining was established by sizing the number of memory words that would change as the vehicle configuration changes. The same iterative process was utilized. In some cases a percentage was utilized by our software personnel best judgement and experience from developing software on similar programs under contract to MDAC.
- (12) We review the GFE from other programs and establish quantities, and type available for use on the Tug program.

### Tug Checkout Philosophy

- A. Factory Checkout (post-manufacturing)
  - 1. Tug/GSE Interface Test and Continuity Test The electrical interfaces between the Tug and GSE will be tested to verify that the proper impedance exists looking into the Tug. (The GSE will be checked for proper operation by appropriate self-test procedures.)

    The Tug's wire-harnesses will also be continuity tested to prove correct wiring and electrical conduction. These tests will be completed before power is first applied. Purpose of these tests is to minimize

- the possibility of vehicle damage due to wiring anomalies during the ensuing power-on testing.
- 2. Subsystem Testing This phase of the testing involves any calibration of components on the Tug that must be accomplished before power is turned on. Power is then applied to vehicle buses and independent subsystems sequentially energized and verified for proper power consumption. Additional calibration of certain Tug components may take place at this time.

Independent testing of each subsystem follows with tests designed to detect failures of out-of-tolerance conditions down to the Line Replaceable Unit (LRU) level. Individual measurements will use the smallest tolerances which can be reliably measured which indicate the proper function of any component. These tolerances generally correspond to the tolerances stated in the component specifications plus any measuring system uncertainty figure.

In some cases, complete subsystem checkout cannot be accomplished during post-manufacturing testing because of the need for extraordinary conditions involving cryogenic temperatures, propellant flow, engine ignition, hypergolic fuels, etc. In such circumstances, testing will be accomplished to the greatest extent possible using simulators and/or software simulation techniques. It is possible that pre-assembly testing of these components under proper conditions must suffice until prelaunch conditions provide the necessary environment for final component validation.

3. System Testing - Once all calibration and subsystem testing are complete, a system test in which all subsystems are turned on and operated together will be performed. Special real-time and off-line data analyses will verify that no incompatibility or interference situation exists. A generalized flight sequence will be followed during this test.

Additionally, this test will provide a time for preliminary flight software to be loaded and partially validated.

For a selected number of early Tugs, an EMC test will be run in conjunction with the system test in order to obtain sufficient data to determine effect of electromagnetic radiation.

Measurement tolerances for system testing will not be as severe as those used for subsystem testing. The intent in this case is to use the measurements to indicate proper operation of total subsystems rather than individual components or LRUs. Fault isolation during system testing may use tighter tolerances, however.

### B. Launch Site Testing

The testing which a Tug receives at the launch area is essentially of two classifications. The first class is the normal scheduled maintenance and checkout which each Tug receives after each mission. The other class is maintenance and checkout which was not scheduled and is done because of data received from the Tug during flight. This data may indicate hard failures or may provide additional data points from which trend analysis can show imminent failures. (Similar to Airline checkout philosophy).

1. Testing on Tugs which have just returned from a mission - These tests are performed in the Safing area and consit mainly of a test of the fuel cells (program Option 2 and 3F only) before they are deactivated. The Tug goes next to the Tug Processing Facility where scheduled and unscheduled maintenance is performed, re-validation checks are made, calibration and testing of the scheduled calibration items is done, and an "all systems test" is run. Measurement tolerances for these tests are similar to those of the corresponding tests done during post-manufacturing checkout, taking into account any differences in measuring systems.

When this testing is complete, the Tug may go into a storage area for an indefinite length of time or it may continue processing for immediate launch.

For those Tugs continuing processing, the next test area will generally be the Spacecraft Mating Facility where the Tug payload is installed. Checkout here will involve testing of the Tug hardware and the interface which supports the payload.

The next test area is the Tug-Orbiter Mating Facility where the Tug is placed in the Orbiter cargo bay and electrically mated. It is recognized that some launch situations will require Tug-Orbiter mating on the launch pad. The checkout performed in either situation is identical. The flight software for both the Tug and Orbiter-Tug checkout computer will be loaded and validated after mating. The Orbiter-Tug interface will also be functionally validated.

Final Tug hardware and software validation will occur on the pad with a Simulated Flight Test in which the flight software and an integrated vehicle can together be used in a simulated flight situation. Checkout tolerances will be those used in flight except in certain cases where the ground computer intervenes with special checkout or fault isolation routines. This flight test is followed by propellant loading and the final countdown. These procedures involve a certain amount of testing to insure proper loading, flight readiness, etc., however, the testing is minimal and uses measurement tolerances which indicate go-no go situations rather than detailed component calibration information. This status monitoring is done through umbilical wiring, downlink readouts, and possibly a direct computer memory access capability.

2. Testing Tugs after storage - Tugs entering storage were essentially ready for payload mating, but because of the calibration drift which occurs with time, a full calibration and

verification cycle, including individual subsystem tests and the final all systems test, must be accomplished in the Tug Processing Facility before payload mating. The subsystem tests are necessary because subsystem data from the last flight may no longer reflect the true Tug condition. These subsystem tests will generally be identical to those used in post-manufacturing chec,out except for differences made necessary by the checkout equipment and facilities.

3. Testing on New Tugs - These Tugs enter the Tug Processing Facility and receive calibration of those devices which require it prior to each launch. An all systems test is then performed and the Tug continues the launch preparation process.

It is assumed that new Tugs have just completed post-manufacturing checkout and therefore do not need full calibration and subsystem testing. If there is any delay which exceeds calibration time limits, a new Tug must be treated as if it had been in storage and undergo full calibration and subsystem checkout.

#### GSE - Option Summary

#### Option 1 Features:

- (a) GSE is sized for fleet size of 13 vehicles for cradles, covers and transporters.
- (b) Guidance and Navigation checkout equipment GFE from Delta program.
- (c) Battery checkout GFE from Saturn program.
- (d) Factory GSE is shipped to VAFB to become launch checkout equipment for one pad. Feasible since schedule delivery of 13 vehicles allows enough time to accomplish this.
- (e) Provide only one pad of GSE at VAFB since launch rates are low from WTR and one set of hardware can support program launch rate from WTR.
- (f) Utilizes maximum GFE from Saturn program where possible to support KSC.

#### Option 2 Features:

- (a) GSE is sized for fleet size of 13 vehicles for cradles, covers, and transporters.
- (b) New Guidance and Navigation checkout equipment is required.
- (c) New fuel cell checkout equipment is required.
- (d) New laser radar checkout equipment is required.
- (e) Factory GSE is shipped to VAFB to become launch checkout equipment for one pad. Feasible since schedule delivery of 13 vehicles allows enough time to accomplish this.
- (f) Provide only one pad of GSE at VAFB since launch rates are low from WTR and one set of hardware can support launch rate from WTR.
- (g) Utilizes maximum GFE from Saturn program where feasible to support KSC.

#### Option 3 Initial Features:

- (a) GSE is sized for fleet sizes of five vehicles for cradles, covers, and transporters.
- (b) All other features are the same as option 1.

#### Option 3 final features:

- (a) GSE is sized for a fleet size of nine vehicles for cradles, covers and transporters.
- (b) Features are the same as option 2 except two pads of GSE and provided at WTR and factory set is available for depot maintenance or future production. In options 1, 2 and 3 initial the factory set of hardware

has been deployed to VAFB as the launch checkout equipment. In option 3 you attain low DDT&E during the initial phase and still have GSE developed during the final configuration to support any configuration checkout and testing turnaround rate. The factory set can be utilized for modification and development of future changes or be moved to the launch site to enable faster turnaround at either KSC or WTR as the situation warrants the higher launch rates.

- 11.6.2 GSE Description Sheets
- All GSE Description Sheets can be found in Appendix E. Section 11.10.
- 11.6.3 Alternate Site GSE

Alternate Sites were eliminated by groundule and thus this section is not applicable.

#### Refurbishment/Reuse Philosophy

The refurbishment/reuse analysis is an essential part of the development of a reusable space tug — one which is capable of performing the required type and number of missions with the minimum DDT&E, Production and Operations costs. The cost of reuse primarily depends on the magnitude and frequency of refurbishment requirements and the fleet size to which they are applied. Therefore, a basic objective of this analysis is to determine means of minimizing the refurbishment requirements over the program life. Reusability is expressed as the number of reuses a Tug can achieve before reaching a point at which the original reliability level cannot be restored on the basis of technical or economic feasibility.

The MDAC refurbishment/reuse philosophy considers the Tug vehicle and its subsystems capable of operating throughout the program life with refurbishment/ replacement of subsystem life-limited components as required. This philosophy is based on the premise that the structures subsystem is the primary consideration in determining an optimum number of reuses. Structures analyses reveal no life limitation for this subsystem and include an evaluation of flight and ground stress loads, fracture mechanics and structures materials. The other subsystems-Thermal Control, Avionics, Propulsion and Orbiter Interface are not life limited at the subsystem level; however all subsystems will experience scheduled and unscheduled maintenance  $(\overline{M})$  and refurbishment  $(\overline{R})$  at the assembly, component or lower levels of detail during the the life of the Tug program. Table 11.7-1 summarizes the Tug subsystem life limitations.

refurbishment characteristics requirements and associated costs per refurbishment and over a spectrum of 20, 50 and 100 reuses. These data are shown in Tables 11.7-2 through 11.7-21. The maintenance/refurbishment cycle functional flows are shown in Section 11.3.3, the time lines are contained in Section 11.3.6 and the task descriptions together with the GSE and manpower requirements are documented in Section 11.3.7.

The number of reuses for subsystem components was derived from:

- Analysis of Tug subsystems and components
- Component manufacturer's recommendations regarding service life and refurbishment criteria in terms of operating hours and cycles.
- Reliability predictions
- Engineering judgement based on experience with similar equipment designs.

Increasing the number of missions before refurbishment (reducing refurbishment frequency) impacts the DDT&E investment by establishing a requirement to;

- Develop/test long life components
- Develop/test high reliability components

In summary, no life limitations are evident at the Tug vehicle and subsystem level; however, there are components with limited life at WBS level 6 and below. These life limitations together with the associated refurbishment criteria, frequency and cost are shown in Tables 11.7-1 through 11.7-21.

#### Tug Checkout Philosophy

- A. FACTORY Checkout (post-manufacturing)
  - interfaces between the Tug and GSE will be tested to verify that the proper impedance exists looking into the Tug. (The GSE will be checked for proper operation by appropriate self-test procedures). The Tug's wire-harnesses will also be continuity tested to prove correct wiring and electrical conduction. These tests will be completed before power is first applied. Purpose of these tests is to minimize the possibility of vehicle damage due to wiring anomalies during the ensuing power-on testing.
  - 2. Subsystem Testing This phase of the testing involves any calibration of components on the Tug that must be accomplished before power is turned on. Power is then applied to vehicle buses and independent subsystems sequentially energized and verified for proper power consumption. Additional calibration of certain Tug components may take place at this time.

Measurement tolerances for system testing will not be as severe as those used for subsystem testing. The intent in this case is to use the measurements to indicate proper operation of total subsystems rather than individual components or LRUs. Fault isolation during system testing may use tighter tolerances, however.

- B. Launch Site Testing
  - The testing which a Tug receives at the launch area is essentially of two classifications. The first class is the normal scheduled maintenance and checkout which each Tug receives after each mission. The other class is maintenance and checkout which was not scheduled and is done because of data received from the Tug during flight. This data may indicate hard failures or may provide additional data points from which trend analysis can show imminent failures.
  - 1. Testing on Tugs which have just returned from a mission These tests are performed in the Safing area and consist mainly of a test of the fuel cells (program Option 2 and 3F only) before they are deactivated. The Tug goes next to the Tug Processing Facility where scheduled and unscheduled maintenance is performed, re-validation checks are made, calibration and testing of the scheduled calibration items is done, and an "all systems test" is run. Measurement tolerances for these tests are similar to those of the corresponding tests done during postmanufacturing checkout, taking into account any differences in measuring systems.

When this testing is complete, the Tug may go into a storage area for an indefinite length of time or it may continue processing for immediate launch.

For those Tugs continuing processing, the next test area will generally be the Spacecraft Mating Facility where the Tug payload is installed. Checkout here will involve testing of the Tug hardware and the interface which supports the payload.

Independent testing of each subsystem follows with tests designed to detect failures or out-of-tolerance conditions down to the Line Replaceable Unit (LRU) level. Individual measurements will use the smallest tolerances which can be reliably measured which indicate the proper function of any component. These tolerances generally correspond to the tolerances stated in the component specifications plus any measuring system uncertainty figure.

In some cases, complete subsystem checkout cannot be accomplished during post-manufacturing testing because of the need for extraordinary conditions involving cryogenic temperatures, propellant flow, engine ignition, hypergolic fuels, etc. In such circumstances, testing will be accomplished to the greatest extent possible using simulators and/or software simulation techniques. It is possible that pre-assembly testing of these components under proper conditions must suffice until prelaunch conditions provide the necessary environment for final component validation.

3. System Testing - Once all calibration and subsystem testing are complete, a system test in which all subsystems are turned on and operated together will be performed. Special real-time and off-line data analyses will verify that no incompatibility or interference situation exists. A generalized flight sequence will be followed during this test.

Additionally, this test will provide a time for preliminary flight software to be loaded and partially validated.

For a selected number of early Tugs, an EMC test will be run in conjunction with the system test in order to obtain sufficient data to determine effect of electromagnetic radiation.

The next test area is the Tug-Orbiter Mating Facility where the Tug is placed in the Orbiter cargo bay and electrically mated. It is recognized that some launch situations will require Tug-Orbiter mating on the launch pad. The checkout performed in either situation is identical. The flight software for both the Tug and Orbiter-Tug checkout computer will be loaded and validated after mating. The Orbiter-Tug interface will also be functionally validated.

Final Tug hardware and software validation will occur on the pad with a Simulated Flight Test in which the flight software and an integrated vehicle can together be used in a simulated flight situation. Checkout tolerances will be those used in flight except in certain cases where the ground computer intervenes with special checkout or fault isolation routines. This flight test is followed by propellant loading and the final countdown. These procedures involve a certain amount of testing to insure proper loading, flight readiness, etc., however, the testing is minimal and uses measurement tolerances which indicate go-no go situations rather than detailed component calibration information. This status monitoring is done through umbilical wiring, downlink readouts, and possibly a direct computer memory access capability.

2. Testing Tugs after storage - Tugs entering storage were essentially ready for payload mating, but because of the calibration drift which occurs with time, a full calibration and verification cycle, including individual subsystem tests and the final all systems test, must be accomplished in the Tug Processing Facility before payload mating. The subsystem tests are necessary because subsystem data from the last flight may no longer reflect the true Tug condition. These subsystem tests will generally be identical to those used in postmanufacturing checkout except for differences made necessary by the checkout equipment and facilities.

3. Testing on new Tugs - These Tugs enter the Tug Processing
Facility and receive calibration of those devices which
require it prior to each launch. An all systems test is then
performed and the Tug continues the launch preparation process.

It is assumed that new Tugs have just completed postmanufacturing checkout and therefore do not need full calibration and subsystem testing. If there is any delay which exceeds calibration time limits, a new Tug must be treated as if it had been in storage and undergo full calibration and subsystem checkout.

## Table 11.7-1 (Sheet 1 of 2) TUG SUBSYSTEM LIFE LIMITATIONS

Subsystems/Components	Life Limiting Factors
Structures	None Evident
<ul><li>Fuel Tank and Support</li><li>Oxidizer Tank and Support</li></ul>	
<ul><li>Body Structure</li><li>Thrust Structure</li><li>Meteoroid Shield</li></ul>	
Payload Interface	
• Fuel Tank Insulation • Oxidizer Tank Insulation	None Evident
Insulation Purge  Avionics	None Evident
<ul> <li>Data Management System</li> <li>Guidance, Navigation</li> <li>and Control</li> </ul>	None Evident  IMU requires refurbishment after  2,000 hours
Communications	Tape recorders require refurbish- ment after 1,000 hours
• Instrumentation	None Evident
• Electrical Power	Primary Power and TVC Batteries are expendable - Replaced after each flight. Fuel cells require replacement after 5,000 hours.
<ul> <li>Power Distribution and Control</li> </ul>	None Evident
Propulsion	
Main Engine	Category I and IIA RL-10 Engines require refurbishment after 5 hours and/or 190 starts
Main Engine Support	None Evident
• ACPS Engines	Mono-propellant thrusters require catalyst bed replacement after 4,000 seconds burn time
ACPS Engine Support	None Evident

### Table 11.7-1 (Sheet 2 of 2) TUG SUBSYSTEM LIFE LIMITATIONS

Subsystems/Components	Life Limiting Factors
Orbiter Interface	None Evident
• Structures	
• Interface Panels	
Abort Provisions	

Table : 11.7-2

IMU REFURBISHMENT CHARACTERISTICS

(Hours)  1t Ground Total  54 90  54 90	Refurbishment	Missions	Refurbishments per No. of Reuses	shments of
Flight Ground Total 36 54 90 144 54 198 36 54 90	Onersting	Scheduled		
15 15 1	~	Refurbishment	20 50	100
45	2K	22	ı	#
45	2K	10	8	01
i	2K	22	ı	4
2 144 54 TAO	2K	10	a,	97

Note:

1. Gyros are the principal refurbishment requirement

2. IMU refurbishment estimated at 30% of new IMU cost

Teble : 11.7-3

TAPE RECORDER REFURBISHMENT CHARACTERISTICS

Total         Operating         Scheduled         20         50         10           26         1K         38         -         1           104         1K         10         2         5           26         1K         38         -         1           26         1K         38         -         1           104         1K         10         2         5		Đ. Ç	000 0	Operating Time (Hours)	9	Refurbishment Criteria-	Missions Before	Ref.	Scheduled Refurbishments per No. of Reuses	nents of
2     13     13     26     1K     38     -     1       2     52     52     104     1K     10     2     5       I     2     13     13     26     1K     38     -     1       F     2     52     52     104     1K     10     2     5	Communications Tape Recorders	Tug	Flight	Ground	Total	Operating Time (Hours)	Scheduled Refurbishment	80	50	700
2         52         104         1K         10         2         5           1         2         13         26         1K         38         -         1           8         2         52         104         1K         10         2         5	Program Option 1	Q	13	13	· %	JK	38	•	н	Q
I. 2     13     26     1K     38     -     1       F     2     52     104     1K     10     2     5	Program Option 2	CV.	25	<b>2</b> 2	104	1K	10	a	<b>5</b>	97
2 52 52 10 <sup>4</sup> 1K · 10 2 5	Program Option 31	QJ	13	13	56	J.K	38	1.	H	N
	Program Option 3F	N	25	25	101	<b>*</b>	10	Q	~	2

Note:

1. After each flight

Change Tape Cassettes Clean Tape Heads Clean Inside of recorder

Tape transport mechanism, bearings, etc., are principal refurbishment requt.

Recorder refurbishment estimated at 25% of new recorder cost.

Table . 11.7-4

PROGRAM OPTION BATTERY REQUIREMENTS

Expendable	Total	Battery Quantity Per Tug	ry ity ug		Estimated Cost for Program	Est1 Costs	Estimated Replacement Costs per No. of Reuses	.acement of Reuses
Battery	Program			Estimated	Uption		ber ing - an	AP.
Replacement Costs	Quantity *	Primary Power	TVC	Cost per Replacement	Filgnt Schedule	8	50	00τ
Program Option 1	225	2	-	\$37.3K	\$8,392.5K	974	1,865	3,730
Program Option 2	220	ı	-	\$ 2.3K	\$ 506K	91	115	230
Program Option 3I	150	Q	ч	\$37.3K	-\$5,595K	<b>4</b> 46	1,865	3,730
Program Option 3F	. 222	•	- H	\$ 2.3K	\$ 510.6K	917	115	230

\*Total Program Quantity = Total Number of Program Scheduled Flights less the Ship Set delivered with each new tug plus 5 percent spares to compensate for ground operations contingencies.

Table //,7-5 FUEL CELL REUSE CHARACTERISTICS

	Meximum Flights	Oper	Operating Time (Hours)	B	Replacement Criteria- Operating	Missions Before	S Replac Per N	Scheduled Replacements per TUG Per No. of Reuses	r TUG ses
Fuel Cells	Per TUG	Flight	Light Ground Total	Total	(Hours)	Replacement	8	50	100
Program Option 2	25	ነሳፒ	9	150	5,003	33	•	н	, m
Program Option 3F	37	<del>ተ</del> ተፒ	vo	150	5,000	33	1	H	m

Table - //.7-C

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Fuel Cell Replacement Requirement Program Option 3F Flight Requirement Expendable Flights Reflight/Loss 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7						×								4
_		Fuel Cell Replacement Requirement Program Option 3F	Flight Requirement	Expendable Flights	Reflight/Loss	TUG ID	5	9	7	8	6	10	Total Replacements	

NOTE: 1. Y = Yearly, C = Cum., and R = Replacement
2. Two fuel cells/replacement

Table //.7-7
MAIN ENGINE REFURBISHMENT CHARACTERISTICS

•	Service	rvice Life	Refurbishm Criteria	Refurbishment Criteria	Usage per Mission	per	Missions	Refu Per	Refurbishments Per No. of Reuses	ments
Main Engines	Cum. Hours	Cum.	Cum. Hours	Cum. Cycles	Cum. Hours	Cum. Cycles	Scheduled Refurbishment	20 50	50	001
		90.		001	0.5	6	10	QI	<b>~</b>	ខ្ព
Category I RL-10	Inder	)	<b>,</b> 4		. Ir	. 0	10	CV.	~	ន
Category IIA RL-10	Indef.	190	, ,	) ) )	, u	٠ ٥	8	н	Q	<b>1</b>
Category IV RL-10	Indef.		3 5		. 0	· 0	50	н	N	<b>~</b>
Aerospike	2 3	1200	4 4	8 8	0.5	, o.	. 8	<sub>,</sub> H	CN	5

Table 11.7-8
MAIN ENGINE REFURBISHMENT COSTS

					6	Scheduled	ed.
-	Average	Refurbishment		Missions	ရှိ ပ	Costs - \$K	men t *K
	Production	88 B %	Cost per	before	Per	Per No. of Reuses	Reuses
Main Engines	Unit Cost - \$K	of New Engine Cost	Refurbishment \$K	Scheduled Refurbishment	8	50	100
Category I RL-10	188	30	146	10	292	730	1,460
Category IIA RL-10	558	8	167	10	334	835	1,670
Category IV RL-10	628	30	188	50	188	376	046
Aerospike	767	33	253	50	253	909	1,265
Advanced Space Engine	837	33	276	80	276	552	1,380

Table 11.7-9 Main engine refurbishment characteristics comparison by program option

	m re	Criteria	Refurbishment Criteria	Usag Mis	Usage per Mission	Missions		per per Program Option	nerurorsmments per Program Option	g g
Mein Engines Hours	Cycles	Cum. Hours	Cum. Cycles	Cum. Hours	Cycles	Scheduled Refurbishment	Н	0	HE .	3
										1
Today	ספר	<b>ن</b>	190	0.5	0	2	81	18	75	18
Category 1 ML-10	Í	•		•		(	q	ď	9	ζ.
Category IIA RI-10 Indef.	190	ĸŇ.	190		ο,	2	9	2	4	}
,	006	. <u>C</u>	300	0.5	0	50	Φ	O/	4	9
Category IV RL-10 . Inder.	n	ì.	}	• 1	` (	ć	ø	O	<b>-</b> 4	9
Aerospike 50	1500	ន	300	0.5	o,	3	>	<b>N</b>	٠.	`
Advanced Space Engine 40	1200	97	300	0.5	<b>.</b>	50	Φ	o	<b>#</b>	•

Table //.7-/0
MAIN ENGINE REFURBISHMENT COST COMPARISON BY PROGRAM OPTION

Du as a % Cost per before Programent Scheduled 1 2  Engine Cost \$K Refurbishment 1 2  30 146 10 2,628 2,62  30 167 10 3,006 3,00  30 188 20 1,504 1,69  33 276 20 2,208 2,48		Average	Refurblahment		M as long		Scheduled Refurbishment Costs - \$K	led shment - \$K	
Unit Cost — or New Arrive Scheduled SK         Refurbishment AK         Refurbishment Refurbishment I         Scheduled I         1         2         31           488         30         146         10         2,628         2,628         1,752           10         558         30         167         10         3,006         2,004           5         30         188         20         1,504         1,692         752           767         33         275         2,024         2,277         1,012           ngine         837         33         276         20         2,208         2,484         1,104		Production	8888	Cost per	before		Program	Option	
488       30       146       10       2,628       2,628       2,628       1,752         10       558       30       167       10       3,006       2,004         5       628       30       188       20       1,504       1,692       752         767       33       253       20       2,024       2,277       1,012         ngine       837       33       276       2       2,208       2,484       1,104	Main Engines	Unit Cost -	of New Engine Cost	Refurbishment \$K	Scheduled Refurbishment	ı	2	31	3.6
0         558         30         167         10         3,006         3,006         2,004           628         30         1,88         20         1,504         1,692         752           767         33         253         20         2,024         2,277         1,012           gtne         837         33         276         2,208         2,484         1,104	Category I RL-10	88†	30	146	10	2,628	2,628	1,752	2,628
628         30         188         20         1,504         1,692         752           767         33         253         20         2,024         2,277         1,012           gine         837         33         276         20         2,208         2,484         1,104	Category IIA RL-10	558	30	167	10	3,006	3,006	2,004	3,006
767 33 253 20 2,024 2,277 1,012 Space Engine 837 33 276 20 2,208 2,484 1,104	Category IV RL-10	. 628	30	188	50	1,504	1,692	752	1,128
837 33 276 20 2,208 2,484 1,104	Aerospike	191	33	253	20	2,024	2,277	1,012	1,518
	Advanced Space Engine	837	33	276	20	2,208	2,484	$1,10^{4}$	1,656

7able 11.7-11

Octobory I Ni-Johns         Ri-Johnson Requirement         80         81         85         84         85         86         87         87 <th></th> <th></th> <th></th> <th></th> <th>+</th> <th></th> <th></th> <th>-</th> <th></th> <th></th> <th></th> <th></th> <th><del> -</del></th> <th></th> <th>-</th> <th></th> <th></th> <th></th> <th></th> <th></th>					+			-					<del> -</del>		-					
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y, C = Cum.         X         C         BC         Y         Y         Y         C         BC         Y				-				-		ļ									N	رج
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7.5/k 11.7-12

Category IIA RL-10 Muin Engine Change Requirement Program Ontion 2	10 ye Requirement	8	æ	82	. 83	ಕೆ	85	<b>%</b>	87	88	&	8	Total
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								1	3 3 0	0 - - - - -	7 14 1	11 25 1	2/52
- 0									<u>_</u>		9 16 0	9 25 1	25/2
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TABL 11.7-13

Category I RL-10 Main Engine Change Requirement				_											- · ·
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Table 11.7-14

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							-							1		1	

Table .. //, 7 - /5 ACPS REFURBISHMENT CHARACTERISTICS

	Thrusto	Thruster Burn Time Data	Deta	>	Valve Cycle Data	ta	Sel Refu	Scheduled Refurbishments	ed ments
Mono Propellant ACPS	Catalyst Life in Seconds	Burn Time per Mission	Missions Before Refurb.	Valve Cycle Life	Duty Cycles per Mission	Mssions Before Refurb.	% % %	No. of Reuses 20 50 100	100
36 Hour Mission  • 25 Lb. Thruster  (Forward Firing  Axial & All Tangential)	000°t	9	100	200K	-	806	•	•	. •
• 25 Lb. Thruster (Aft Firing Axial)	000° †	οηε	. 21	200K	520	38#	н	4	80

Note:

Mission impulse = 16,291 lb sec with equal distribution of burn time.

Aft firng axial thrusters burn an additional 300 seconds/thruster for main propulsion propellant settling.

Table //.7-/6

# ACPS REFURBISHMENT COSTS

ACPS Thrusters -	Average Production Unit Cost	Quantity per	Missions Before Scheduled	Cost per Refurbishment	Refurb \$K - r	Scheduled Refurbishment Costs - \$K - per No. of Reuses	d Costs - f Reuses
Mono-Propallant	\$K	Tug	Refurbishment	per Tug	50	50	100
36 Hour Mission							
• 25 Lb Thruster (Aft Firing Axial)	5,98 (1)	<i>-</i> 4	ឌ	9.6 (2)	9.6	38.4	76.8

Note:

(1) Per Thruster

(2) Refurbishment Cost estimated at 40% of New Ihruster Cost.

Table: 11.7-17

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ACPS (Mono-Propellant) Thruster Change Requir Progrum Option No. 1	ACFS (Mono-Propellant) Thruster Change Requirement Progrum Option No. 1		8	·-··	•		· · · ·	8	· · · · · ·	€	83		<b>ಪೆ</b>		€Ď.	8		8		₩	81		8			&		8		Total	
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3					<del></del>	0	-	80	0	9	777	0	ଷ	0	01 01	22	22	24	н											24/2	-
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5					<del>                                     </del>	-	~	2	0	-3	9	. <del></del>	ន	0	4	777	#	18	اه	8	8	~	22	0	N	72	_			2/12	
9							64	ત્ય	0	- 27	0 9		ន	0	4	777	-3	82	٥	~	8	N i	52	0	cv	77.			_	2/12	
7	•														8	<u>8</u>	-	12	ы	-	9	m	22	0	8	쿲	_		_	2/12	
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6					1							$\dashv$								-	0	m	ឧ	0	<b>ø</b> !	2	7	72	-	2/72	
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## Table 11.7-18

ACPG (Mono- Thruster Cl	ACPS (Mono-Propellant) Thruster Change Requirement Program Option No. 31		8	·	ਬ ਬ			82		83			ಪೆ		8			8	<b> </b>	87		8	88		66	6		Total
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Expadbl. Filghts	lights			-					-									-		ר		. 1			8		$\dashv$	(£)
Reflight/Loss	880			-				-	-		1																$\dashv$	4
		1							-													ŀ	-				-+	149
Tug ID	Y * Yearly, C * Cum. TC = Thruster Change	74	2	ુ 1	0	TC TC	>-	υ	TC Y	5	TC	X	ບ	TC Y	<u>ပ</u>	TC	<b>×</b>	C. I	TCY	ဎ	ည္	٠,	ဥ	<del>بر</del> ن	ت ت	TC		C/TC
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			$\vdash$	┼	-	<u> </u>			<del> </del>	-	-			t —		<u> </u>												
Total Thru	Total Thruster Changes	1	-	-	┤		<u> </u>	2	<del>                                     </del>		m	ļ	7			8		-		-			0		2			12
Note: 4 Th	Note: 4 Thrusters/Change		İ	1			1		1			İ		İ														

11-368

Table 11.7-19

ACPS REFURBISHMENT CHARACTERISTICS

		Thruste	Thruster Burn Time Data	e Data		Valve Cycle Data	Data	Scheduled Refurbishments	\$ .
	Quantity	Thruster	Burn	Missions	Valve	Duty	Missions	Reuses	
Bi Propellant ACPS	Per Tug	Life in Seconds	Time per Mission	Before Refurb.	Cycle	Mission	Refurb.	20 50 100	8
6 Day Mission									
ACPS Engines						٠			
• 100 Lb Axial	<b>60</b>	180K	517	348	1	1	•	i i.	1
• 25 Lb Tangential	∞	180K	837	215			i	1	
ACPS Engine Support									
<ul> <li>Axial Thruster</li> <li>Valve Cycling</li> </ul>	i	1	1	1	300K	2536	118	: :	ŀ
• Tangential Thruster Valve Cycling	1	1	1	l	300K	2734	109		

Note:

1. Axial Thruster Impulse = 51,723 lb sec

2. Tangential Thruster Impulse = 20,937 lb sec

Table 1.7-20 ACPS REFURBISHMENT CHARACTERISTICS — STORABLE VS CRYOGENIC

			\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$		Missions	Be P.	Scheduled furbishmen	Scheduled Refurbishments per
			Operating Time		before	No.	No. of Reuses	uses
	ACPS Candidates	Service Life	per Mission	Refurbishment Criteria	Scheduled Refurbishment	80	20 50 100	100
	Mono-Propellant - 25 lb Thrust	Indefinite	340 вес	4К вес	12	τ	#	80
•	Cryogenic - 25 lb Thrust	Indefinite	340 sec	ЭК вес	56	0	н	ო

Note:

Refurbishment Criteria for Cryogenic ACPS was estimated at 50 percent of the operating life of a Category I RL-10 Main Engine before refurbishment. The RL-10 and the Cryogenic ACPS have similar components and wear life.

Table //, 7-2/ ACPS REFIRBISHMENT COSTS - STORABLE VS. CRYOGENIC

	Average Production	Refurbishment as a % of Average	Cost per	Missions before	Rer	Scheduled Refurbishment Costs Per No. of Uses	ment Uses
ACPS Candidates	Unit Cost \$ K	Production Unit Cost	Refurbishment \$ K	Scheduled Refurbishment	50	50	100
Mono-Propellant - 25 Lb Thrust	861	1.1%	9.5 (1)	.12	9.5	9.5 38	92
• Cryogenic - 25 Lb Thrust	1316.6	15%	197.5 (2)	56		197.5	197.5 592.5
		:					

Notes:

(1) Mono-Propellant ACPS refurbishment costs include only four axial (aft firing) thrusters.

Cryogenic ACPS refurbishment costs include only the two primary turbomachinery/gas generator packages. (2)

#### 11.7.1 Maintenance Levels/Planning

The MDAC Space Tug Maintenance  $(\overline{M})$  Refurbishment  $(\overline{R})$  Concept minimizes  $\overline{M}/\overline{R}$  requirements while maintaining a satisfactory degree of launch on time probability together with the required level of subsystem reliability to assure missions success. It is patterned after the commercial airlines "On Condition Maintenance" philosophy which monitors subsystem health and thus precludes unwarranted maintenance and refurbishment on subsystems, assemblies, and components which are functioning properly. Subsystem health is monitored by a combination of the following techniques:

- a. Operational instrumentation data consisting of subsystem performance measurements which are telemetered during flight via ground link.
- b. When the Tug is out of range of a ground tracking station, these data are recorded on board for later transmission.
- c. Post Flight/Receiving Inspection
- d. Automated subsystem checkout (ground) of those performance characteristics not readily adaptable to inflight monitoring.
- e. Use of onboard checkout capability for fault detection and isolation.

Fundamental to this concept is the definition of subsystem line replaceable units (LRUs) to the lowest feasible level and the ability to fault isolate to that level. The basic repair philosophy is the replacement of LRUs and requires a maintenance/refurbishment analysis that considers repair vs throwaway and the optimum level of repair of LRUs. A system of rotable spares will be employed whereby a faulty LRU is replaced at the launch site with a servicable item from the spares inventory. The faulty item, if repairable, is returned to the factory/depot for repair and is then rotated back to the launch site inventory. This approach combines Bench/Shop Maintenance and Depot Maintenance thus eliminating redundancies in high dollar value GSE. The factory/depot repair schedule is made responsive to launch site operations requirements.

The Maintenance/Refurbishment  $(\bar{M}/\bar{R})$  technical approach/methodology is not sensitive to individual Tug configurations; however, the cost of an  $\bar{M}/\bar{R}$  cycle and depot maintenance will vary with different configurations. These variations have been expressed in the  $\bar{M}/\bar{R}$  inputs to the cost model for each configuration in terms of Manhours/ $(\bar{M}/\bar{R})$  cycle, equivalent units of production

hardware for operational spares and depot maintenance cost as a percentage of average subsystem hardware cost.

The definition of maintenance levels, maintenance planning methodology and the development process for maintenance procedures and a complete maintenance program is contained in Appendix B.

11.7.2 Impact on Turnaround Cycle

The failures risk analysis and spares planning data discussed in Section 6.11.4.1 have provided unscheduled maintenance predictions and indications of the magnitude of launch risk.

Table 11.7-22 shows the unscheduled maintenance man hours (MMH) expected as an average for a Tug turnaround cycle. These man hours are for LRU replacement and checkout in the Tug when the work is done in the normal maintenance and refurbishment cycle. The down time is a function of manloading by the particular skills required. The use of highly reliable space qualified hardware and proper qualification testing is essential to achieving a Tug design with this low maintenance man hour capability. Figure //.7-/ shows a probability distribution for this unscheduled maintenance. The 90th percentile value indicates the total MMH expected not to be exceeded more frequently than 10 out of 100 maintenance and refurbishment cycles.

Predictions have been made for the risk of an anomaly occurring in the Tug equipment during the period of integrated systems test and servicing prior to Shuttle liftoff. (Ref. functions 2.1.7 through 2.4.4 as shown in FFD, Section 11.3.3). The total risk for each subsystem was divided into unreliability (risk of liftoff with a degraded component) and risk of pad loadout. The Tug risk of pad loadout is a function of subsystem verification capability (risk of failure x % testable). The risk of pad loadout prediction is 5 per 100 launches. The peak risk period is during Tug servicing, resulting from the operational stresses applied to instrumentation, fluid systems and activation of subsystem equipment just prior to launch.

The unreliability at launch prediction is \* probability, \* unreliable Tugs per 1000 launches. This risk represents the share of prelaunch anomalies present which are not detectable by the verification process. This low value represents the high verification capability expected from the combined Tug and Orbiter.

A trade study was conducted to estimate the effect of reduced maintenance time on these predicted performance values. An evaluation was made for each

<sup>\*</sup>Options 1 and 3I only. Unreliability is 0.010 probability, 10 Tugs per 100 launches for Options 2 and 3F.

TUG REPAIR COSTS

Date 0-29-73
Rev. 9-3-73

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Structure Fuel Tunk Oxidizer Tank							<u> </u>	0.030 0.030	88	0.9 0.9				
Hank Support Body Structure Thrust Structure Moteoroid Burrier Payload Interface					······································	<del></del>	<u>'                                    </u>	0.050 0.010 0.100 0.030	2888	1000 0000			•	
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Duration 6 Days

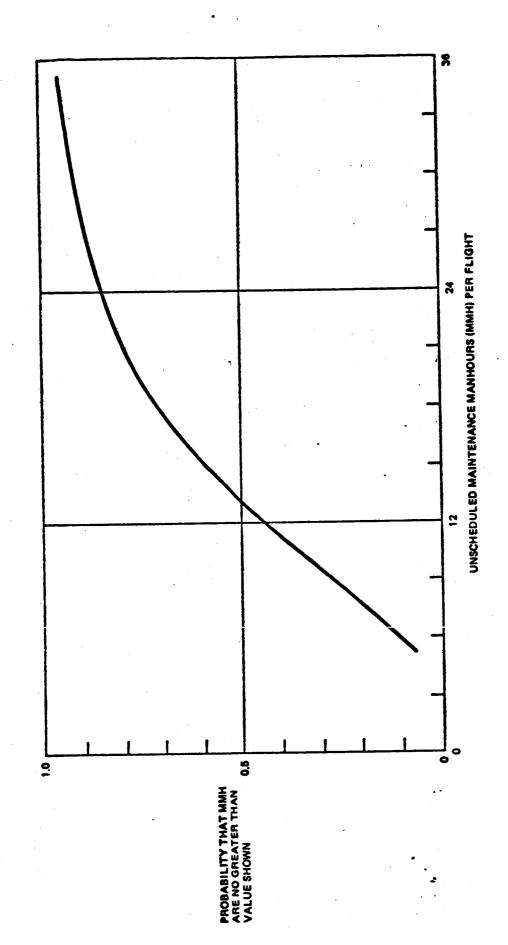
Configuration 3F

Date 8-30-73 Rev. 9-3-73

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TOO HEPAIR COSTS

Notes MMH / Structural Propulation Avionica 15.78 1.1.13 4.38 1.42 0.36 9.46 MMI/Flight/Location 1,1,12 3.00 26.28 1.17 9.3 0.12 0.18 0.67 0.19 0.25 0.0 Corrective Muintenance 5.34 2.16 1.1.11 0.50 1.20 1.95 0.26 0.39 0.34 Rep. æ 2 222409 2 2 9 တ္တ မ မ 8883 88 0.012 0.018 0.067 0.041 0.041 0.146 0.322 0.096 1.798 0.379 0.5½7 0.237 0.060 0.008 2.595 0.065 0.013 0.130 0.034 0.030 0.946 0.034 0.040 0.001 1.2.1 2.3.9 2.4.2 2.4.3 Fit. System Test/Verification Fost Flight Post Raff & Preflight ě Propulsion Total Repairs and MM/Fit. Structure Avionics Location Configuration 1.1.6 1.1.7 Total Ret. & Spin A/C 3A3 -Semi Cond. Storeble Biprop. I, RLIO Trident Cold He ME.I H.A. Feedline Condition-Subsystems/Elements Data Management and Instrumentation Power Distribution Payload Interface Meteoroid Barrier ACPS Engine and Support Communications Electrical Power Fill and Drafa Pressurization Thrust Structure Utilization Eody Structure Orlentution Avionics/Fower Thermal Control Oxidizer Tanh Propellant Tank Support Kain Engine Support Pheumat.c and Control Fuel Tank Propulsion **Feed** Structure lent. Purge



11-377

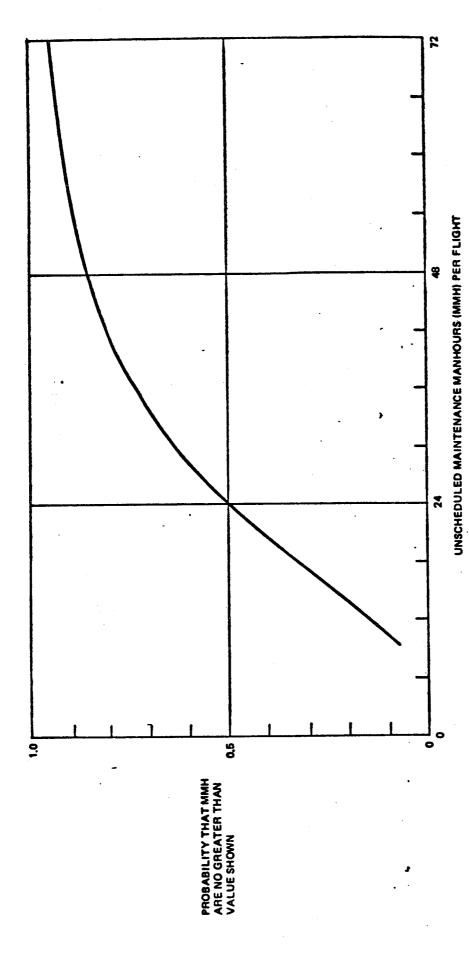


Figure 6.13.74 Probability Distribution - Unscheduled Maintenance Manhours per Flight (Options 2 & 3F)

54.7

1.7

11-378

function to estimate the effect of reducing test hours which in effect would reduce the probability of finding faulty equipment early in the maintenance and refurbishment cycle. The functions, total times and minimum considered potentially feasible are shown in Table 11.7-23. In each case the results of time reduction in one function was evaluated for its effect on later functions. With these reductions it is estimated to increase risks of pad loadout by 24% and launch unreliability fivefold.

The increase to almost five unreliable Tugs per 100 flights indicates that a serioud man hour reduction (31%) is not cost effective. Careful analysis during design development may determine cost savings available in test time or equipment utilization to provide cost savings without increasing unreliability.

Table 11.7-23

# MAINTENANCE TEST & VERIFICATION OPERATIONS BY FUNCTION

1.1.6 Post Flt.
127.5
10.0 12.5
35.0 65.0 65.0
(I) 232.5 (2) 232.5 (3I) 202.5 (3F) 235.0
70 Avionics 55 Propulsion

### 11.7.3 Effect on Logistics

The Logistics technical approach/methodology is not sensitive to individual Tug configurations; however, the costs associated with the dollar value of a logistics inventory will vary with the design complexity of different configurations. The transportation costs are indirectly influenced by configuration, but only as a function of fleet size. The training and inventory control and warehousing functions are relatively insensitive to configuration differences. Variations in dollar value of the logistics inventory have been expressed in the Maintenance and Refurbishment inputs to the cost model.

11.7.4 Tug/Payload Integrated Checkout
The Tug/Payload Integrated Checkout will be performed as follows at the locations indicated.

### TPF

 Connect payload simulator to Tug and verify wiring and electrical load inputs using Tug Data Management System.

### PPF/TPF

- 1. Perform continuity check on Tug prior to mating with payload.
- 2. Mate payload with Tug.
- 3. Radiate payload through Ground Telemetry Station and readout telemetry.

### MCF

- 1. Check electrical interface between Shuttle and Tug payload.
- 2. Load software into Mission Payload Specialist's console.
- 3. Perform integrated systems test with payload, Tug and Shuttle all in the loop.
- 4. Radiate telemetry to Ground TM Station via either open or closed loop and readout telemetry.

### 11.7.5 Onboard vs Ground Checkout - Program Option 1 and 3I

### SUMMARY

Onboard checkout is cost effective, even though the operations benefits are zero, the large manpower required due to the large manpower requirements necessary to support the Tug/Shuttle function at the launch sites. If the Shuttle/Tug functions weren't a constraint, there would be an even greater savings due to the additional personnel required at each TPF and launch site to operate the additional GSE.

Other advantages of onboard checkout not reflected in the cost estimates include:

- a. Ground and mission flexibility and reduced Tug dependence on the Shuttle.
- b. Less cost impact to changes (ECP's) that affect the Tug vehicle and which would further result in changing all sets of GCE.

The GSE description sheets define the additional GSE required and their associated costs which total \$9.654M of which 3.08 is additional DDT&E cost.

The vehicle cost consists of developing a self-checkout capability in the Star Tracker, additional wiring and the addition of (4) RMU's. The Built-In Test Equipment consists of self check capability in the Signal Conditioning Unit, Response Unit and Remote Multiplexer and a manual self-check capability in the Data Control Unit and System Control Unit. Additional checkout software are also required.

The MDAC onboard checkout philosophy utilizes the vehicle DMS system and checkout software to perform functional vehicle checkout and fault isolation.

achieved through a combination of built-in/centralized test equipment. The DMS requires access to those parameters required to support inflight redundancy management. In flight redundancy management refers to the process of fault detection and isolation to the level at which redundant components can be switched. "Checkout only" parameters are those required to fault isolate to the LRU level. The definition of "checkout only" parameters is a function of the actual flight software logic and is therefore rather subjective at this time. The "checkout only" parameters would also be available in flight but software is not included in our estimate to perform in flight fault isolation to an LRU level unless required to support redundancy management.

The degree of built in versus centralized versus ground test equipment is dictated primarily by existing designs, feasibility, effect on reliability, and development cost.

The increase in vehicle cost is due primarily to the development of BITE particularly in the DMS which is a new design. The cost of additional interface channels is negligible since these units must be developed in any case and the parameters normally exist on test connectors although some additional signal conditioning may be required.

The increase in weight is due to the additional DMS interface units required less the additional wire required to route the checkout parameters to these connectors panels. (NOTE: Test connector panels may not be required for some electronics boxes since access to the box test connector may be available in the forward skirt.)

INCREASED AVIONICS WEIGHT ODATA MANAGEMENT MIU'S OBITE WIRING AND CONNECTORS	18.72 LB				WITHIN THE TIME CONSTRAINT
DECREASED GROUND OPERATIONS COST PERSONNEL REQD LESS MAINTENANCE "LESS GSE TO MODIFY RESULTING FROM PROGRAM CHANGES (ECPs) (NOT COSTED)		*0		ЗЪ М.	TO SHUTTLE FUNCTIONS
DECAFASED TURTAROUND SCHEDULE OREDUCED GSE CALIBRATION OFASTER SUBSYSTEM, SYSTEM AND C/D CHECKOUT OREDUCED DATA ANALYSIS		•0		TOTAL COST SAVINGS = \$5.634 M.	THIS RESULTS FROM TUE MANPOWER SIZED TO ACCOMPLISH TUG TO SHUTTLE FUNCTIONS WITHIN THE TIME CONSTRAINT IMPOSED BY SHUTTLE.
DECREASED GSE COST  **REDUCED GSE COMFUTER SIZE **REDUCED CALIB.** GSE **GCOMTON SUB- SYSTEM, SYSTEM COUNTDOWN GSE **COUNTDOWN GSE **CLIMINATE FAULT	ISOLATION GSE  OLESS INTERCON- NECTIONS	-9.654M			THIS RESULTS FROM TUE, MANPOINDED BY SHUTTLE.
INCREASED AVIONICS COST OBITE OADDITIONAL DMS INTERFACES OADDITIONAL VEHICLE WIRING	+4.02M				*THIS RESU IMPOSED B
100\$ INCREASE 9 7 7 6 5	3 — 3 — OLLARS 2 — IFF. 1 — VER	INTINON 1	m = n 0 11-385	- 0 0	DECREASE

ONBOARD CHECKIXIT PROVIDE GROUND AND MISSION PLEXIBILITY AND REDUCES SHUTTLE DEPENDENCE. જં

ONBOARD CHECKNUT IS COST EFFECTIVE WITH ONLY SLIGHT INCREASE IN VEHICLE COST WITH A REDUCTION IN GSE COST.

ä

CONSLUSION:

NAME: COMMAND RESPONSE	UNIT	EQUIPMENT NO.	
FUNCTIONAL REQUIREMENT	(s):		
This unit shall generat	te hardline stimuli for	r testing Tug hardware and will	be
		the digital portion of the GSE	
checkout system.			
2,300.11			
EQUIPMENT DESCRIPTION:			
This unit is composed of	of 2 SCUs, 8 PCUs, 2 D	CUs, 16 RMus, 40 connectors,	
terminal board assembli	les, and 9500 wire ter	minations. Similar to DSV-4B-13	30.
\$	1.050.000 (DE	VELOPMENT COST)	
<b>. \$_</b>	230,000 (ហរៈ	IT COST)	
EQUIPMENT CATEGORY:		·	
NEW_X	MODIFIED	AS IS 50% of DSV-4B-130	
1ST YEAR REQ'D	NUMBER AVAII	ABLE	
EQUIPMENT UTILIZATION:		•	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
	ETR (TPF)	1	
	ETR (LAUNCH PAI	) 1	
	ETR (LAUNCH PAI	) 1	
	WTR (TPF)	1	
	WTR (LAUNCH PAI	) 1	
	FACTORY	1	
TOTAL DECUEPTS			
TOTAL REQUIRED		OTAL COST \$ 2,430,000	

NAME: GROUND EQUIPM	evt test set		EQUIPMENT NO.	
FUNCTIONAL REQUIREMENT	IT(S):			
The Ground Equipment	Test Set shall prov	ride an ov	verall check of the GSE	system
when the Tug is not c	onnected. The test	set shal	ll verify the satisfact	ory
operation of that por	tion of the GSE not	verified	by self test programs	•
EQUIPMENT DESCRIPTION	₩:			•
patch panel (1000 pt	s), 35 connectors,	test poir	nt panel (200 TP), term	inal
board assemblies and	8500 wire terminati	ons simil	ar to DSV-4B-132.	
				<del></del>
	\$ 1,660,000	(DEVELOS	PMENT COST)	
		UNIT CO	•	
	\$ 373,000	_ (00111 00	/SI <b>/</b>	
EQUIPMENT CATEGORY:			and a new le	
NEWX	MODIFIED		AS IS 30% of DSV-4B	-132
1ST YEAR REQ'D	NUMBER	AVAILABLI	?	·.
EQUIPMENT UTILIZATION	Y:	•	•	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATIO REQUIRE		NUMBER REQUIRED	
	ETR (LAURIC	H PAD)		
	ETR (LAUNC	H PAD)	1	
	WTR (TPF)		1	
·	WTR (TPF)		1	
;	WTR (LAUNC	H PAD)	1	
	FACTORY		1	
TOTAL REQUIRED	6	m∧m + ч	. COCID & 3 POP 000	
TOTAL REMOTIVE		TOTAL	cosr \$ 3,898,000	_

NAME: INTERFACE JUNCTION	BOX	QUIPAFIT NO
FUNCTIONAL REQUIREMENT(S)		
This unit provides vehicle	circuit protection and	the patching interface
between the Tug and the GS	EE.	
EQUIPMENT DESCRIPTION:		
Two bay junction box cons	isting of test point pane	ls, fuse and circuit breaker
panels, patch panels, and	terminal boards. Simila	r to DSV-7-100A3.
۸. 2	50,000 (DEVELOPME	or cost)
<del></del>		
\$ <u>2</u>	93,000 (UNIT COST	,
EQUIPMENT CATEGORY:	•	
NEWX	MODIFIED	AS IS 30% of DSV-7-100
1ST YEAR REQ'D_	NUMBER AVAILABLE	
EQUIPMENT UTILIZATION:	• .	
Functional Flow Block Number	LOCATION REQUIRED	number Required
	ETR (LAUNCH PAD)	1
	ETR (LAUNCH PAD)	1
	ETR (TPF)	1
	WTR (TPF)	1
	WTR (LAUNCH PAD)	1
	FACTORY	1
TOTAL REQUIRED	TOTAL	cont \$ 3,108,000

NAME: CABLE NETWORK K	IT	EQUIPATET NO.
FUNCTIONAL REQUIREMENT(S		
		cables for connection of the
Tug umbilical and black l	box test connectors to th	e interface junction box and
for connection of the ju	nction box to the Tug che	ckout GSE.
EQUIPMENT DESCRIPTION:		•
This unit is composed of	the following cable type	s: 5 four pin power cables,
thirty 60 pin cables, an	d five 39 pin cables.	
· · · · · · · · · · · · · · · · · · ·		
\$	20,000 (DEVELO	PMENT COST)
<u> </u>	23,000 (UNIT CO	OST)
· · · · · · · · · · · · · · · · · · ·		
EQUIPMENT CATEGORY:		
	MODIFIED	
1ST YEAR REQ'D_	NUMBER AVAILABLE	
EQUIPMENT UTILIZATION:		
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	number Required
	ETR (TPF)	1
	ETR (LAUNCH PAD)	1
Mary may make make a make a make a make a make a make a make a make a make a make a make a make a make a make	ETR (LAUTICH PAD)	1
	WTR (TPF)	1
·	WTR (LAUNCH PAD)	1
	FACTORY	1
TOTAL REQUIRED	6 TOTA	L COST \$ 218,000

# 11.7.5 Onboard vs Ground Checkout -- Program Option 2 and 3F

Onboard checkout is cost effective, even though the operations benefits are zero, due to the large manpower requirements necessary to support the Tug/Shuttle function at the launch sites. If the Shuttle/Tug functions weren't a constraint, there would be an even greater savings due to the additional personnel required at each TPF and launch site to operate the additional GSE.

Other advantages of onboard checkout not reflected in the cost estimates include:

- a. Ground and mission flexibility and reduced Tug dependence on the Shuttle.
- b. Less cost impact to changes (ECP's) that affect the Tug vehicle and which would further result in changing all sets of GSE.

The GSE description sheets define the additional GSE required and their associated costs which total \$12.872M of which 4.10 is additional DDT&E cost.

The vehicle cost consists of developing a self-checkout capability in the Star Tracker, additional wiring and the addition of (4) RMU's. The Built-In Test Equipment consists of a self check capability in the Signal Conditioning Unit, Response Unit and Remote Multiplexer, and a manual self-check capability in the Data Control Unit and System Control Unit. Additional checkout software are also required.

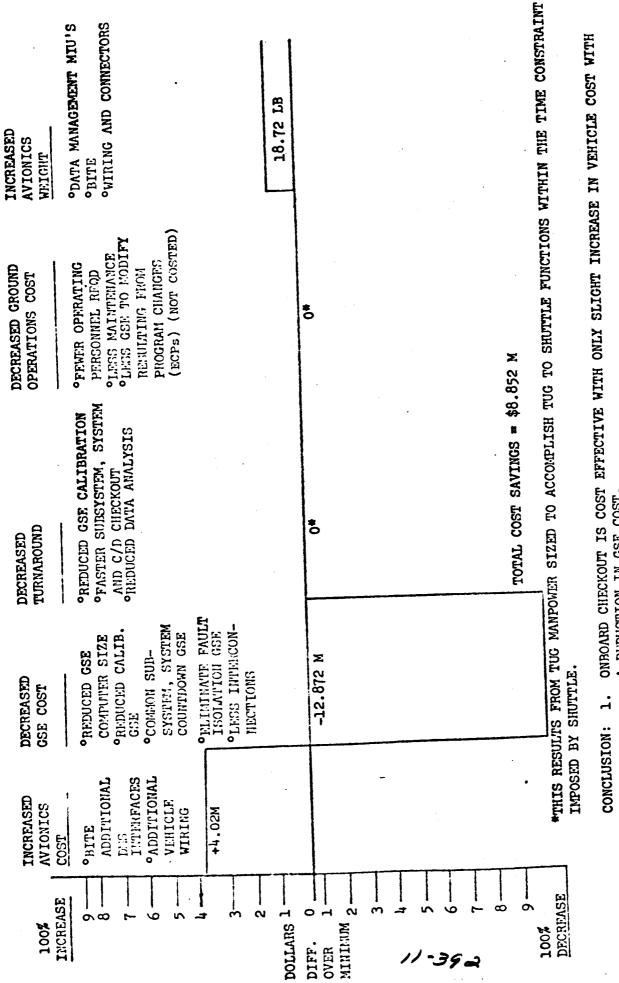
The MDAC onboard checkout philosophy utilizes the vehicle DMS system and checkout software to perform functional vehicle checkout and fault isolation to the LRU level with minimal GSE support. The onboard checkout capability is

achieved through a combination of built-in/centralized test equipment. The DMS requires access to those parameters required to support inflight redundancy management. In flight redundancy management refers to the process of fault detection and isolation to the level at which redundant components can be switched. "Checkout only" parameters are those required to fault isolate to the LRU level. The definition of "checkout only" parameters is a function of the actual flight software logic and is therefore rather subjective at this time. The "checkout only" parameters would also be available in flight but software is not included in our estimate to perform in flight fault isolation to an LRU level unless required to support redundancy management.

The degree of built-in versus centralized versus ground test equipment is dictated primarily by existing designs, feasibility, effect on reliability, and development cost.

The increase in vehicle cost is due primarily to the development of BITE particularly in the DMS which is a new design. The cost of additional interface channels is negligible since these units must be developed in any case and the parameters normally exist on test connectors although some additional signal conditioning may be required.

The increase in weight is due to the additional DMS interface units required less the additional wire required to route the checkout parameters to these connectors panels. (NOTE: Test connector panels may not be required for some electronics boxes since access to the box test connector may be available in the forward skirt.)



A REDUCTION IN GSE COST.

ONDOARD CHECKOUM PROVIDE GROUND AND MISSION FLEXIBILITY AND REDUCES SHUTTLE DEPLIDENCE. તં

NAME: COMMAND RESPONS		EQUIPMENT NO.	
######################################	(c)-		
FUNCTIONAL REQUIREMENT	•		
This unit shall generat	e hardline stimuli f	for testing Tug hardware and w	ill be
able to transfer Tug si	gnals from the Tug t	to the digital portion of the	GSE
checkout system.			
EQUIPMENT DESCRIPTION:			
This unit is composed o	f 2 SCUs, 8 PCUs, 2	DCUs, 16 RMUs, 40 connectors,	
		erminations. Similar to DSV-4	
			·
			<del></del> -
\$	1,399,650 (r	DEVELOPMENT COST)	
· <b>\$</b>	306,590 (u	UNIT COST)	
EQUIPMENT CATEGORY:			•
•	MODIFIED	AS IS 50% of DSV-4B-	130
	,	•	130
IST YEAR REQ.D	NUMBER AVA	AIIABLE	
EQUIPMENT UTILIZATION:		· ·	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
	ETR (TPF)	1	
	ETR (LAUNCH P	PAD) 1	
	ETR (LAUNCH P	PAD) 1	
	WTR (TPF)	1	
	WTR (LAUNCH F	PAD) 1	
	FACTORY	1	
	ندارا <u>ن ده بر بردا</u> کنت به پردان کنداند.		

NAME: GROUND EQUIPMENT	rest set	EQUIPMENT NO.
FUNCTIONAL REQUIREMENT(	s):	
•		erall check of the GSE system
	nected. The test set shall	
	on of the GSE not verified	
EQUIPMENT DESCRIPTION:	· · · · · · · · · · · · · · · · · · ·	
l patch panel (1000 pts)	, 35 connectors, test poin	t panel (200 TP), terminal
board assemblies and 85	00 wire terminations simil	ar to DSV-4B-132.
·		•
\$	2,212,780 (DEVELOPM	ent cost)
<b>\$</b>	497,209 (UNIT COS	T)
EQUIPMENT CATEGORY:	• • • • • • • • • • • • • • • • • • •	•
NEWX	MODIFIED	AS IS 30% of DSV-4B-132
1ST YEAR REQ'D	NUMBER AVAILABLE	
EQUIPMENT UTILIZATION:	•	•
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED
	ETR (LAUNCH PAD)	1
	ETR (LAUNCH PAD)	1
-	WTR (TPF)	1
	WTR (TPF)	1
	WTR (LAUNCH PAD)	1
	FACTORY	1
TOTAL REQUIRED	mona a	cosr \$ 5,196,034
AND MERCOZINIU	TOTAL	COUL & 29220302

NAME: INTERFACE JU	UNCTION BOX	EQUIPATIT NO.
	rugarm (o ).	
FUNCTIONAL REQUIR		•
This unit provide:	s vehicle circuit protection an	d the patching interface between
the Tug and the G	SE.	
EQUIPMENT DESCRIP	TION:	
Two bay junction	box consisting of test point pa	mels, fuse and circuit breaker
panels, patch pan	els, and terminal boards. Simi	lar to DSV-7-100A3.
	\$ 466,550 (DEVELO	PMENT COST)
	\$ 390,569 (UNIT (	cost)
EQUIPMENT CATEGOR	Y:	
HEM X	MODIFIED	AS IS
1ST YEAR REQ'D_	NUMBER AVAILABL	F
EQUIPMENT UTILIZA	TION:	
FUNCTIONA	HOGATION	NUMBER
Flow bloc Number	REQUIRED	RDQUIRED
	ETR (LAUNCH PAD)	1
	ETR (LAUNCH PAD)	1.
	ETR (TPF)	1
	WTR (TPF)	1
	WTR (LAUNCH PAD)	
	FACTORY	

NAME: CABLE NETWORK KIT	# 1 T	DULIMINI IIO.	<del></del>
•			
FUNCTIONAL REQUIREMENT(S)	electrical interconnect	sables for connecti	on of the
Tug umbilical and black b	ox test connectors to the	interface junction	t box and
for connection of the jun	ction box to the Tug check	cout GSE.	
			<del> </del>
MOUIPMENT DESCRIPTION:		·	
This unit is composed of	the following cable types	5 four pin power	cables,
thirty 60 pin cables, and			
\$;	106.640 (DEVELOPME	NT COST)	
\$	30,659 (UNIT COST	<b>)</b>	
EQUIPMENT CATEGORY:			:
NEWX	MODIFIED	AS IS	
1ST YEAR REQ'D	NUMBER AVAILABLE		
EQUIPMENT UTILIZATION:			
FUNCTIONAL	LOCATION	number	
FLOW BLOCK NUMBER	REQUIRED	REQUIRED	
	ETR (TPF)	1	_
	ETR (LAUNCH PAD)	1.	_
		1	-
	ETR (LAUNCH PAD)		
	WTR (TPF)	1	-
	WTR (LAUNCH PAD)	11	-
	FACTORY	1	<b>-</b>
TOTAL REQUIRED	6 TOTAL	cost \$ 290,554	

### 11.8 TUG FLEET SIZE

11.8.1 Active Tug Fleet Size

The Active Tug Fleet size is summarized in Figure 8.11.1-1 and 8.11.1-2.

### 11.8.2 Total Program Fleet Size

The Tug fleet sizing analysis was based upon the flight schedule developed as a result of the mission accomplishment analysis (as reported in Volume 4). The capture analysis identified the flight by flight mission accomplishment. With the flight schedule and associated flight mode and the effect of reliability, the fleet size necessary to carry out the activity was developed.

The total program fleet size is 13 vehicles of which 2 must be available in the year of IOC.

### 11.8.3 Factors Influencing Fleet Size

Table 11-1 shows the schedule of flights per year by Tug I.D. number. At the top of the chart, the number of flights per year is shown and the number of Tug expendable flights. The number of Tugs required were established by first determining the number of Tugs necessary to accomplish the 1990 requirements and working backward from that point to 1984. The maximum number of

TUG ACTIVE FLEET SIZE OPTION 31

YEAR	1 82 83 84 85 86 87 86 89 80	2 2 3 2 2 2 1 0 0 0	
	70 81	1 2	
	ETR	NO, OF 7465	

WIR	8	100	78	83	3.04	* 2	98	67	88	8	68	
W. C. 1 1165	0	0	0	/	0	0	0	9	$\theta$	0	0	

OPTION 3E 2 YR. IOC DELAY

	86 87 86 89 90	2 / 0 0 0 0	
YEAR	3 84 85	2 2	
	828	2 3	
	80 81	0	
	ETR	No. OF TUES	

					YEAR	2					
WITE	8	/8	18	80 81 82 83 84 8	84	BS	85 86 87 88 88 %	87	88	80	8
NO.0F 7465 0	O	0	0	<u>\</u>	0 0 0 0	0	0	0	0	0	0
		-			-						I

F160RE 8.11.1-1

TUG ACTIVE FLEET SIZE OPTION 3F

ETR 30 81 82 33						
	40	3 84 85 36 87 8	87	8	26 95	0
VO, OF 7265 0 0 0 0 0	2	7 7	3	4	M	W

					`	EAR					
WIR	${\mathcal B}$	18	82	83	8364	285	30	10	88	900	99
NO.OF TUGS	O	θ	0	0	\		\	\	1	\	>

OPTION 3F 2 YR. IOC DELAY

	90	M	1
	•	10)	
	87 88 89	4	
	87	w	
	SS 26	2	
2	2	2	
131	8 4	2	
	63	0	
	82 83	0	
	-	0	
	18 08	0	
	ETR	No. 05733	

					YEAK	~					
MITE	$\mathcal{G}$	18	82	83	84	85	98	87	88	89	8
No.OF TUGS	0	0	Ø	0	-	+	_	1	+	-	-
	l										

TABLE 11 -1

EQUAL USAGE SCHEDULE

OPTION 3

			 	·											• •		
TOTAL	366	8	32	32	33	33	33	33	33	33	33	33	54	17			
06	01	-								9	9	10	6	6			
89	41	8					2	5	2	. 5	10	. 10	5	5			
88	37						4	ব	7	2	3	10	10				
87	01					5	η	†	77	10	10	3					
86	ፒተ	1			5	8	9	9	9	9	4						
85	4.1				7	9	8	8	8	4							
3.5	71	2	η.	η	5	7	6	6	6								;
83	36		10	10	10	9											
82	22		7	6	2	77											· 
81	21		6	89	†1												
80	m	50	2	1						, a							
	NUMBER OF FLIGHTS	NUMBER OF EXPENDED TUGS	TUG ID 1	a	Ю	4	5	9	7	80	6	10	11	12		R TTGETS :	

flights any Tug can perform in a year is established first by summing the Tug ground turnaround time and the mission time which results in the minimum mission turnaround time. In Option 3 the ground turnaround time is as follows:

Configuration	Ground Turn- around Time (Days)	Average Mission Time (Days)	Average Mission Turnaround Time (Days)
Initial	28.0	1.7	29.7
Final	29.0	3.3	32.3

Using this number and assuming that the maximum number of flights that an expended Tug can make in the year that it is expended is 6 (one-half the maximum turnaround in a year), the fleet of 5 for 1990 is established. Working backward from there it can be seen that in 1989 the three expendable requirements and the necessary vehicles used in 1990 make up the inventory requirements. In 1984 the initial Tug flights are limited by its capabilities (it is able to perform only 17 of the 44 flights) thus the final configuration initial year fleet is established to accomplish the remaining flights. The initial Tug fleet size of 4 is established by the 1983 requirement of 36 flights.

The resulting data show that to carry out the operations a total of 12 Tugs is required of which 4 are initial and 8 are final configurations.

Using the Government ground rules for reliability losses, 4 additional vehicles are required (1 initial and 3 final configurations). Thus the total fleet size necessary is 16 of which 2 initial configurations are required at IOC (1980) and 4 final configurations at IOC (1984).

The major influence on fleet sizing is the number of expendable Tug missions required. If, for example, no expendable missions were required the required fleet size could be reduced to nine vehicles including reliability losses (4 initial and 5 final vehicles).

### 11.9 COST DATA

The ground operations have been analyzed and costed in two separate "breakouts" of the elements involved. The first breakout is the standard Work Breakdown Structure for the study, as defined by the Government and included in the cost analysis program. The second breakout is the "standard numbering system for tasks identified in the functional flow diagrams," as provided by the Government and included in all the ground and launch operations analyses conducted in the study. These two breakouts are correlated in Table 11.9-1 to indicate the MDAC approach to resolution of the apparent discontinuities between the two accounting methods.

The ground operations cost data are provided on Table 11.9-2, as developed for both ETR and WTR (where applicable). These cost data are listed in agreement with the ground and launch operations numbering system and organization of Section 6.11 of this document, as shown on the left half of Table 11.9-1.

The costs presented are a direct function of ground crew size and the methodology employed to optimize manpower. Accordingly, to help substantiate the cost estimates, trade study sheets for Determination of Ground Crew Size and Innovation Ground Operations Techniques are included. These data are in response to action items 95 and 97.

TABLE 11.9-!

# GROUND OPERATIONS CORRELATION

	GROUND & LAUNCH OPS. NUMBER	WBS ELEMENT
1.1	I	SCHEDULED M&R (320-13/14-01) UNSCHEDULED M&R (320-13/14-02) REFURBISHMNET PLNG (320-13/14-05)
1.2	POST-MAINTENANCE CHECKOUT	POST MAINT CHECKOUT (320-13/14-03)
2.2	TUB SYSTEM & INTEG SYS. C/O SC/TUG MATE	TUG/PAYLOAD MATING & C/O (320-13/14-04)
2.3	SHUTTLE/TUG MATE	TUG/SHUTTLE MATING & C/O (320-09/10-02)
7.2	COUNTDOWN	PRELAUNCH CHECKOUT (320-09/10-03) COUNTDOWN (320-09/10-04)
3.2	SAFE AND SECURE SHUTTLE/TUG DEMATE SC/TUG DEMATE	POST FLIGHT SAFING (320-09/10-06)
FA FO	GROUND SUPPORT EQUIP	

TABLE 11.9-2

31 GROUND OPERATIONS COST DATA

ELEMENT	COST IN	COST IN \$ MILLIONS
	ETR	WTR
LOGISTICS	1.3	3
DEPOT MAINTENANCE	18.2	1.9
MAINTENANCE	0.4	7.0
POST-MAINTENANCE: CHECKOUT	0.1	0.05
TUG SYS C/O & SC/TUG MATE & C/O	2.2	4.0
SHUTTLE TUG MATE	1.1	0.2
COUNTIDOWN	3.1	9.0
POST-FLIGHT OPERATIONS	1.9	0.3
GROUND SUPPORT EQUIPMENT	12.7	11.2
FACILITIES	2.2	1.6

TABLE 11.9-2 (cont.)

# 3F GROUND OPERATIONS COST DATA

ELEMENT	COST IN	COST IN \$ MILLIONS
	ETR	WTR
LOGISTICS	8	CV.
DEPOT MAINTENANCE	32.1	<b>6.</b> 8
MAINTENANCE	11.0	h.7
POST-MAINTENANCE CHECKOUT	ተ•0	0.2
TUG SYS C/O & SC/TUG MATE & C/O	7°.	2.2
SHUTTLE TUG MATE	8.6	1.7
COUNTDOWN	13.1	5.0
POST-FLIGHT OPERATIONS	5.5	2.2
GROUND SUPPORT EQUIPMENT	2.3	٦٠٢
FACILITIES	0	0

### DETERMINATION OF GROUND CREW SIZE (ACTION ITEM 95)

The methodology of ground crew sizing for the cryogenic Tug basically consists of a ten step process. Each process step is described below and illustrated in Figure 1.

### STEP 1: FUNCTIONAL\_FLOWS

For each Tug vehicle configuration option, top level functional flow diagrams were developed to reflect the operational requirements of the following items;

Flight Requirements (NASA/DOD)

- o ETR launch
- o WTR launches

Flight Composition

- o Tug (Basic)
- o Tug with Kick Stage

### STEP 2: TASK DESCRIPTION SHEETS

For each function identified in the functional flow diagrams of Step 1, a task description sheet waw constructed. The title, objective, purpose, location, required equipment, manpower and interface requirements for each functional task is specified on these sheets and are a prerequisite to the development of timelines and manloading.

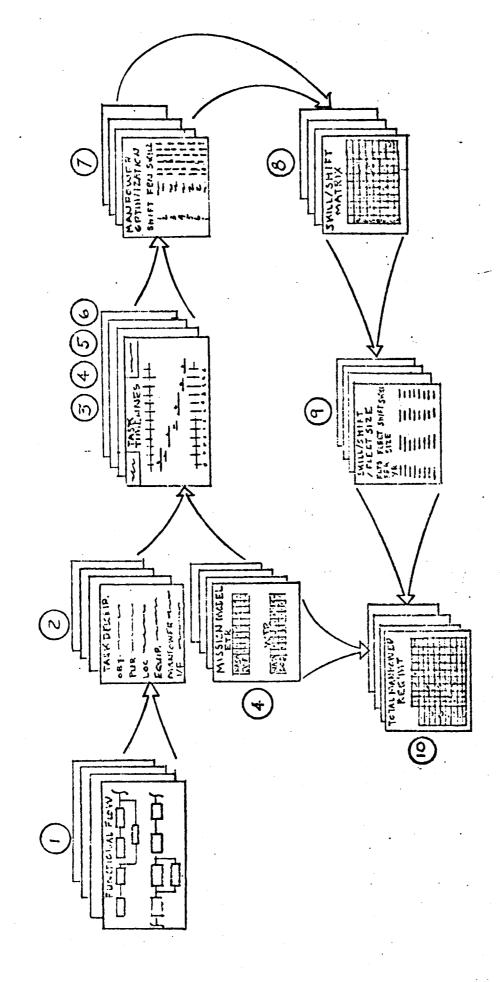


Figure 1

### STEP 3: SUBTASK DEFINITION

Individual subtasks and their respective manpower allocation required to accomplish each functional task were defined utilizing the task description sheets of Step 2 and their timelines to determine the overall time required for each functional task.

### STEP 4: MISSION MODEL ANALYSIS

The mission model for each Tug vehicle configuration option was analyzed for each launch site with regard to number of launches, user (NASA and DOD), flight composition, and mission type (deployment, round trip, etc.) The predominate Tug mission was then selected for detailed analysis and development of task timelines and sequences, and ground and launch operations manning requirements.

### STEP 5: TASK TIMELINES AND SEQUENCE DEVELOPMENT

Based on the predominate Tug mission selected for each Tug vehicle configuration option in Step 4, the appropriate functional task timelines developed in Step 3 were assembled on a sequential hour by hour basis in a manner consistent with the functional flows for each respective Tug option.

### STEP 6: TURNAROUND TIMES

Tug turnaround times were determined and top-level operational bar-chart flows were developed for each Tug configuration option based on the assembled timelines of Step 5.

### STEP 7: SKILL PER SHIFT DETERMINATION

The task timelines of Step 5 were evaluated on a task per flight basis and appropriate manpower skill requirements were optimized utilizing skill sharing techniques where possible.

### STEP 8: MAXIMUM vs. MANDATORY SKILL BREAKDOWN

A skill per shift matrix was developed for each Tug vehicle configuration option utilizing the data derived in Step 7 in order to determine the maximum skill breakdown requirements and the mandatory skill breakdown

requirements during those shifts whose operations are constrained by the Orbiter ground processing schedule.

### STEP 9: MANPOWER vs. FLEET SIZE DETERMINATION

Based on the required on-orbit time and the turnaround time derived in Step 6 for each Tug option, liftoff to liftoff times were determined and the active Tug fleet size for any required launch rate was derived.

Manpower levels for each required skill were then assigned on a per-shift basis accordingly.

### STEP 10:

Utilizing the data generated in Step 9 and the number of required launches per year as specified in the traffic model for each Tug option, a total manpower per skill per shift per year matrix was developed.

The crew size for each Tug option is attached.

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c. Avionics Technicians

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### INNOVATIVE GROUND OPERATIONS TECHNIQUES (ACTION ITEM 97)

#### I MDAC APPROACH

Eleven Tug engineering personnel are mandatory during certain Tug prelaunch operations which are time constrained due to Shuttle ground processing schedule requirements. Evaluation of manpower requirements indicates however that during turnaround shifts during which engineering personnel are required, eleven engineers are required only five percent of the time. During the other seventy-five percent of the time, a maximum of nine engineers is only required.

#### II MDAC POSITION

For those program years requiring four Tug launches per year or less, a field engineering staffing of nine engineers is adequate if, for the five percent of the time when eleven engineers are required, two "home plant" engineers are provided TDY during the five percent peak periods when eleven engineers are required.

Program years during which less than four Tug launches per year are listed below:

TUG OPTION	PROGRAM YEAR	Launch Si <b>te</b>
1	1980	ETR
1	1984	WTR
1	1986	WIR
1	1988	WTR
1	1990	WIR
3	1980	ETR

The savings of two engineers during these program years can be equated to \$384,000 for Option 1 and \$76,800 for Option 3.

#### IV IMPACTS

Providing home plant engineering personnel to the launch site on a TDY basis for limited periods during program years having launch rates of less than four per year does not impact Tug operations and has precedence on current launch vehicle programs.

Operating in this fusion during program years having launch rates greater than four per year is however neither economical nor efficient.

11.10 Appendix A - Trade Study Results

The operational trade studies are reported in the appropriate section and no "appendix" type material was generated.

#### APPENDIX B .

#### MAINTENANCE PLAN

#### MAINTENANCE

The contractor shall develop a maintenance program that provides optimum Tug System support at the test and launch sites. The maintenance program will have as its objective, a minimum expenditure of support resources over the life of the program. The maintenance concept shall be based on the airline philosophy of on-condition maintenance which minimize performance of maintenance tasks on a specific time interval basis. The contractor will develop the status monitoring and failure prediction techniques necessary to employ this concept. A fault isolation capability to a line replaceable unit (LRU) level will be developed, making maximum use of onboard checkout equipment. Wherever feasible, GSE requirements analyses shall recommend the use of multi-purpose test equipment. A maintenance plan will be prepared defining the types and levels of maintenance, maintenance cycle, maintenance organization and maintenance control functions. A maintenance analysis will be conducted to determine maintenance resource requirements for system, subsystem, LRU and component level. During the maintenance cycle, the primary method of system and subsystem repair will be removal and replacement of LRUs. An optimum repair level analysis will have been completed to determine the most cost effective repair location for each LRU. The interface of the maintenance function with the other elements of integrated logistics support will be defined.

#### Maintenance Plan

Prepare a maintenance plan that identifies the analysis and planning necessary to provide a program consistent with airline policies and practices. In order to develop the maintenance plan it is necessary to identify maintenance concepts, policies, constraints and requirements. As nearly as possible the maintenance functions of the reusable Tug are related to present airline practices as developed through operating experience and modified to meet Tug needs.

The plan shall specify the approach used for maintenance support of system maintenance, including such elements as implementation of on-condition maintenance, launch site maintenance policies and practices, joint operational and maintenance personnel utilization, vertical and horizontal vehicle maintenance groundrules and distinction between LRU, maintenance significant and nonmaintenance significant hardware categories. Establish the program authority for these plans, and the manner in which they will be maintained current with program development.

Organization - The Maintenance Plan shall describe the maintenance engineering organization that will plan, establish, perform and control maintenance support of the Tug system. The Plan will also define the program authority of the Maintenance organization, and its relationship to other program organizations; e.g., reliability, test, safety and maintainability.

#### Maintenance Analysis

Define the type and content of maintenance analyses required to establish Level I, II & III maintenance requirements, inspection schedules, maintenance turnaround cycles, GSE, facility interfaces, potential candidates for inflight maintenance, and cost effective procedures. Describe integration and timelines of the maintenance analyses with other Tug program analyses and events. Describe the approach for the utilization of the maintenance data file that enables storage and rapid retrieval of categorized information. The requirement to evaluate field collected maintenance data, and to establish corrective action for apparent problems shall also be considered in the analyses.

The maintenance analyses are performed to identify the system, subsystems and components that require, preventive and/or corrective maintenance. It is based on a systematic analysis of the hardware design to determine the time required to perform each maintenance action and the requirements for specific equipment, facilities, personnel, spares and technical documentation. The analysis is the basic element used in establishing a continuous maintenance program.

#### Maintenance Analysis Format

The maintenance analysis system will be identified and discussed in detail under this heading of the Plan. The technique for tabulation of the data compiled requiring analysis will also be discussed in this section. Instructions for completion of and format samples of the analysis work sheets will be provided. Format of the work sheets shall be mutually acceptable by both the Government and the Contractor.

#### Maintenance Support and Control

Describe the test and operational phase of Tug maintenance control that is required to control and administrate maintenance support operations, (e.g., schedule maintenance activities). The Plan shall describe the approach used for the formulation, conduct and authority of the organization, and the optimum physical locations. Define the relationships of the organization with other field organizations, including the operational contractor, giving special attention to the common utilization of personnel for operations and maintenance requirements.

Reports of flight test and operational maintenance actions will be evaluated to determine the degree of effectiveness of maintenance support operations. Describe the approach to be used in the development and implementation of the Tug system data collection program (such as AFSN 310-1, SSD Exhibit 66-1) that encompasses preparation of action reporting forms, field data collection, data evaluation and development of improvement recommendations, whenever applicable. Identify program needs for the collected field data and describe the using agencies plans for maximum program benefits through this effort.

#### Types of Maintenance

The total system maintenance requirements will be evaluated and segregated in specific types of maintenance, i.e., Postflight, Preventive, Corrective and Calibration. A detailed discussion of the application of these types to the Tug system will be provided in the plan.

#### Types of Inspection

It is anticipated that several categories of inspection will be required, e.g., Acceptance, Preflight, Postflight, Phased, Special Inspections. Each of these categories will be discussed in the plan to show how each is applied to the maintenance program and what each category of inspection is intended to accomplish.

#### Levels of Maintenance

- Three levels of effort will be used in support of the continuous maintenance program:
  - First Actions accomplished directly on the vehicle.
  - Second Actions accomplished, in support of first level, off the vehicle in shops or areas located at the Factory/depot.
  - Third Actions accomplished, in support of first and second levels, requiring specialized skills and equipment.

A detailed definition of each level will be provided in the plan, so that it may be used as a reference when making maintenance level assignments for repairable hardware.

#### Maintenance Philosophy and Concepts

Through evaluation of the analyses, trade-offs and liaison actions, specific maintenance philosophies and concepts will be developed for individual end items, components, assemblies and subassemblies. Such concepts as the following will be included:

- The maintenance program will consist of a structural sampling inspection schedule, a preventative maintenance schedule and corrective maintenance based on the ON-CONDITION concept.
- Corrective system maintenance will be removal and replacement of failed components.
- Application of maintenance status annunciators, maintenance and flight data recorders.

These concepts will be coordinated and integrated with the other affected support activities, e.g., Logistics Engineering, Supply Support, Technical Publications. Training, Operations and Design Engineering. These agreed upon concepts will be recorded in the plan and considered as the baseline program maintenance concept.

#### Support Equipment and Tools

As a product of the Maintenance Analysis, determine and document the support equipment and tools (CFE, GFE and Commercial) required. Additional sources of supplemental information includes Design Engineering, Operations and the Maintainability Task Analysis. These requirements will be reflected in the plan, segregated to the respective levels of maintenance.

#### Skill Levels and Manpower

The objective of this exercise is to identify, (1) the job title (skill level) and (2) the requisites (qualifications), formal education, training and experience associated with each skill (grade). This information will be provided in the maintenance plan for correlation with and use in identifying skills during the Maintenance Analysis Program.

In order to facilitate accurate manpower and training plans during the design phase, it is necessary to quantify each skill level required to support the operational system. These requirements are initially identified through the Maintainability Task Analyses and are thoroughly coordinated with the Personnel and Training Group prior to recording them in the Maintenance Plan as firm requirements.

#### Personnel Utilization Concept

A study will be made to define how maintenance personnel will be cross-trained and utilized in the maintenance, prelaunch and launch activities. The results of this study will be reflected in the Personnel Utilization concepts provided in this maintenance plan.

#### Maintenance Cycle

The maintenance actions defined and expanded during the maintenance analyses are inputs to be integrated into a total maintenance activity. The maintenance actions will be categorized into one of the types of maintenance discussed; assigned a level of maintenance and diagrammed in a Functional Flow Block Diagram (FFBD), when required. Time spans of each task will be plotted in a timeline study and a specific segment of time designated as the "Maintenance Cycle" time. A detailed discussion of the designated maintenance cycle, through the flight test and operational phases, its timeline and FFBD will be provided.

#### Periodic Maintenance Control

The automated documentation and scheduling program for periodic (preventive) maintenance requirements of all GSE, (including GFE) support equipment, and stored and installed flight hardware will be defined. Specific direction as to application of this program to the Space Tug Program will be provided in this portion of the plan.

#### Utilization of Government Owned or Financed Resources

Each requirement involving: facilities, support equipment, tooling or other maintenance resource, will be evaluated in terms of utilizing Government owned or financed resources to satisfy the need. In those areas where Government facilities or resources can be used, appropriate discussions will be provided in the Maintenance Plen. In each instance, maximum use will be made of Government facilities and resources.

#### Coordination and Interface

The various elements and requirements of the plan are coordinated and completely interfaced with Engineering, Facilities, Operations, Publications, Supply Support, Training, and Operational Contractor to assure the requirements and decisions reflected in the Plan are compatible with, and support their planning and concepts.

#### Functional Flow Block Diagrams (FFBD)

In order to accurately perceive the magnitude and scope of specific maintenance requirements, it is necessary to diagram the maintenance action in its logical procedural steps. The maintenance plan will provide guidelines to be followed in preparing these FFBD's.

#### Provisioning Support

This portion of the plan will provide guidelines and parameters of Maintenance Engineering responsibility with respect to support of provisioning activities. Decision making authority will be clearly defined; action to be taken when the provisioning decision is not compatible with the requirements expressed in the maintenance analysis; general outline of the data to be provided and made available during provisioning conferences will be included in this area.

#### Data Collection

To aid in identifying and eliminating potential problems, correcting existing failures, and improving maintenance capability, a maintenance data collection system will be defined and implemented. The data collection will start with component testing, continue through manufacturing, test and operational phases. Because of the minimum number of vehicles produced and limited flight test program there is a need to gather as much data as early as possible to verify the maintenance and logistics program prior to the operational phase.

The method of collecting field data and the techniques to be applied in the processing and analyses of the data will be described in this section of the plan.

#### MAINTENANCE FACILITIES

A Maintenance Facility Program Plan will be prepared. This plan will outline the contractors' approach to identifying facility requirements, existing facilities and how the contractor plans to conduct the facility acquisition effort. Personnel engaged in this activity will be responsible for:

• Conduct "on the spot" evaluations of existing maintenance facilities and prepare Site Selection and Evaluation Report for NASA/DOD.

- Identify to NASA/DOD, specific technical requirements and facility design constraints.
- Prepare facility design concepts to facilitate review and analysis of proposed solutions to facility design trade-off. These concepts will include recommended floor and area plans with room or area names, size, functions, elevation plans, clearances and statements of how electrical and mechanical functions are to be carried out.
- Participate in design reviews with NASA/DOD, architects, et al to support the maintenance facility planning aspect of the program.
- Prepare an Activation Plan which consists of consolidating all schedules, plans and associated actions required for total activation of new or modified maintenance facilities.
- Prepare a Master Equipment List of Real Property Installed Equipment (RPIE) and items of electrical and mechanical equipment and their major components, based on the final facility design.
- A Project Status Report will be prepared and updated periodically, to keep NASA/DOD advised of the status of all incomplete maintenance facilities. An Annual Summary Report will be prepared for each active facility contract which will include a summary of all funding actions, inventory transactions and use of facilities under the total contract during the reporting period.

This activity will be concerned with all locations, i.e., launch site and test sites.

#### MAINTENANCE STATUS REPORTS

Maintenance Status Reports shall be provided to assure proper accounting of all pertinent maintenance elements. The reports will include description of trends, problems and actions taken or deferred. Formal Maintenance Milestone (Schedule) Summary documentation will be initiated as the document for time phasing the Maintenance Program.

#### Appendix C

#### SPARES ANALYSIS/PLANNING (UNSCHEDULED MAINTENANCE)

#### C.1 SPARES QUANTITY AND COST ANALYSIS DATA

The maintainability analyses have addressed unscheduled maintenance requirements. This applies risk of failure analysis methods to prediction of spares requirements. The same basic data were used to predict maintenance manhours, launch reliability and payload changeout risk at the pad (see Section 6.11.7.2). The results of the spares analyses are documented in 3 sets of data contained herein. Cost estimates were introduced into the cost model in terms of initial spares and depot maintenance, measured in terms of equivalent units of production subsystem hardware costs.

The first set of forms entitled preflight verification of subsystems show the failure/anomaly risk analysis basic to the maintenance time and spares cost predictions. The data in the column labeled " $\epsilon = N\lambda KT$ " shows risk of failure (failures per flight).

The next series of forms entitled Tug Spares Analysis show subsystem breakdown to Level 8 and spares quantities. The data from the verification of subsystems form ( $\epsilon$ ) are used to calculate the values shown in Columns 2, 3, 8, and 9. Stock level estimates are made as a function of flight frequency, depot flow time and desired probability of sufficient stock for any contingency. The quantity of initial spares (required at Level I to repair any failure present in a returning Tug, SI) is based on a 0.90 probability of sufficient spares to cover 5 flights without resupply. The estimates for Level II maintenance provides at least 1 of each replaceable item if not qualified in SI for Level 1, plus an additional quantity for higher failure risk items to assure a 0.995 probability of sufficient parts over a 5 flight time span. Depot maintenance costs are based on failure rate, estimated number of flights and % of part costs to handle the cost of the repair cycle (30% used for the latter, for refurbishable items). The quantity of initial spares for each component to repair the Tug are shown under "Component Initial Stock". The quantity of operational spares for each item is shown under "Component Float Stock" and "Subassembly Operational Spares". The worksheets showing the calculation of spares costs for the cost model input sheet are shown in the third set of data.

## C.2 MATHEMATICAL TECHNIQUES USED IN THE ANALYSES The customary failure risk prediction technique used in reliability predictions is based on the formula ENAKT where,

H = Number of parts in the equipment

λ = Failure rate of the part

K = Stress factor for the part for time T (Vibration, heat, etc. effects)

T = Operating time

For the Risk of Failure prediction shown on the form "Preflight Verification of Subsystems," the following values were used

H = Number of components or subassemblies (computer, valve, tank, etc.)

 $\lambda$  = Failure rate of the characteristic item for space

K = Equivalent anomaly factor\*

T = Flight duration + equivalent space time to compensate for shuttle lift off stresses + prelaunch operations time following tug post maintenance checkout. 10 Prelaunch Operations; 178 Equivalent Flight Time

The K factor for additional damage was applied to predict work load. Investigations several years ago indicated that operation of equipment in test after transport to a flight location introduced 5 - 8 times the prior number of failures. This same magnitude value was used here to represent the ratio between actual failures (inherent reliability failure rate) and anomalies (degraded performance, suspect items removed as deficient, or items requiring adjustment or calibration prior to dispatch on a new Tug space mission). Thus, the total spares quantity shown includes both the actual flight failures and correction of anomalies.

The cost models used to calculate spares costs in terms of equivalent assembly (Level 6) and subsystem (Level 5) costs are:

For Initial Spares as a function of assembly cost:

$$ET_{K} = \sum_{j=1}^{M_{j}} so_{j}.R_{j}.c_{j} + cl_{j} \sum_{i=1}^{M_{i}} sr_{i}$$

and

For Operating Spares as a function of assembly cost:

$$\mathbf{EO}_{\mathbf{K}} = \sum_{j=1}^{\mathbf{H}_{j}} \mathbf{SO}_{j}.\mathbf{R}_{j}.\mathbf{C}_{j} + \mathbf{CI}_{j} \sum_{i=1}^{\mathbf{H}_{i}} \mathbf{SO}_{i}$$

and

For Depot Spares as a function of assembly cost:

$$\mathbf{ED}_{\mathbf{K}} = \sum_{j=1}^{\mathbf{H}_{\mathbf{j}}} \mathbf{SD}_{\mathbf{j}} \cdot \mathbf{R}_{\mathbf{j}} \cdot \mathbf{C}_{\mathbf{j}} + \mathbf{C1}_{\mathbf{j}} \sum_{i=1}^{\mathbf{H}_{\mathbf{i}}} \mathbf{SD}_{\mathbf{i}}$$

For Initial Spares as a function of subsystem cost:

$$EI_{L} = \sum_{k=1}^{N_{k}} EI_{K} \cdot C2_{K}$$

Operating or Depot Spares as a function of subsystem costs (EO  $_{L}$  or ED  $_{L}$ ) are found by substituting EO  $_{K}$  or ED  $_{K}$  in the last equation.

The meanings of the symbols used follow:

SI, = Number of initial spares of component j.

SI, = Number of initial spares of subassembly i.

SO; = Number of operating spares of component j.

SO; = Number of operating spares of subassembly i

SD = Number of depot repair kits and/or parts as equivalent components

SD = Number of depot repair kits and/or parts as equivalent subassemblies

C = Cost of component j in equivalent assemblies

 $Cl_j$  = Average cost of subassembly i in equivalent components =  $\frac{c_j}{N_i}$ 

C2 = Cost of assembly k in equivalent subsystems L

R<sub>j</sub> = The ratio of the cost of a spare component j to the cost of a shipset of component j.

PREFLIGHT VERIFICATION OF SUBSYSTEMS
MODEL 1 & 31

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PREFLICHT VERIFICATION OF SUBSYSTEMS
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PREFLIGHT VERIFICATION OF SUBSYSTEMS

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3.0	Avionics												•	
3.1	Data Management 2A	র		\$ \$ \$				•					.194740	
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	Box - Misc.		Computer Function		Subroutines	2.4.1	×	··· · · · · · ·	3	(5)	-	25	(.00 <i>22</i> 75)	
3.1.2	Mod. Interface Unit.			67.3	Computer								.131040	
	Bus Interface Unit		Back up Bus	· ·	Subroutines	2.4.1	Part.		ន		<b>-</b>	25 25	(.018200)	
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	Remote Multplx U		Multiplex Data		Subroutines	2.4.1	Part.		91	4	<b>-</b>	15	(.029120.)	
	Data Interface U		Transfer Data		Sub routines	2.4.1	Part.		<del>-</del>	4	<b>-</b>	15	(.003640)	
	Signal Condit.		Proper Measurement		Subroutines	2.4.1	Part.		<del>-</del>	<i>=</i>	·-	15 50	(.007280)	
3.1.3	DCU			4.6	Subroutines	2.4.1	Part.		1/2	o <sub>ž</sub>	<b>-</b>	1.5 50	.018200	
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PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL 1 & 31

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3.2.1	IMU	×							2/	85	<b>∞</b>	202	.051720	
3.2.1.1	Gyro Absy		Stabilize		Meas. Speed	2.4.4	×		(9)	(4.7)	∞	202	(316410.)	
3.2.1.2	Accellerometers		Displacement	•	Bench Test	1.1.13		×	(9)	(3.4)	<b>&amp;</b>	207	(,006854)	
3.2.1.3	Sensor Electronics		Input-Output Data		Operating Data 2.4.4	2.4.4	×		(2)	(16.4)	∞	207	(120110.)	
3.2.1.4	Power Supply ¢ Elect.		Power to Units		Unit Funct.	4.4.5	×		(2)	(50)	ω	207	(013440)	
3.2.1.5	Housing & Coolent - Misc.		Temp. Cont.		Measure - IM	2.4.h	×			(16.2)	<b>6</b> 0		(308010.)	
3.2.2	Start Sensor		-18-17						م <sub></sub>	8	8	읂	.019200	
3.2.2.1	Sensor		Sense/Track Stars		Light Table	1.1.13		×	(2)	(25)			(000910.)	
3.2.2.2	Stabilization/ Drive		Control Sensor Posit.		Test Response	1.2.1	×	,	(2)	(5)			(.003200)	
3.3	Communications	<u>3</u>		2.66	•					î			040990*	
3.3.1	Antenna	×	Data Output	001	Test For IM	2.4.1	×		.a	3.6	2	15 40	.003960	
3.3.2	Multiplexer	×	Sequence Data	100	Test for IM	2.4.1	×		н	4	φ	21.3	.001760	
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PREPLICHT VERIPICATION OF SUBSYSTEMS

MODEL: 1 & 31

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	TWI		Voltage		Monitor by TM	2.4.1	×		(7)	(11)	∞	15	(092610.)	
	Circuitry		Power Avail		TM Communic.	2.4.1	×		(1)	(5)	∞	112	(.002200.)	
3.3.4	Transponder	ж	Relay Data	8	Interrog.	1.1.13		×	1/2	or Or	<b>&amp;</b>		.004400	
3.3.4.1	PC Board				,				(4)	89	•		(.003520)	
3.3.5	coder	×	Equip. Function	8	TM Command	2.4.1	×		1/2		<b>6</b> 0	112	.001 760	
3.3.6	Processor	н		ಹ			Part.		н.	<b>&amp;</b>	Φ	21.3	.003520	
3.3.6.1	PC Boards		Data Input to IM		Interrog. Df	2.4.1	Part.		a	m	∞	115	.002640)	
3.3.6.2	Circuitry		Data Input to				Part.	·	н	Q,	<b>∞</b>	115	.000800)	
3.3.7	Commd. Encoder	×	Equip. Funct.	907	TM Command	2.4.1	×		н	3.7K	<b>6</b> 0	125	.007480	
3.3.8	Tape Recorders	×		100				×	N	R	<b>6</b> 0	~ <del>.</del>	.021600	
3.3.8.1	Tape Drive Mech		Position Tape		Oper. T.R.	2.4.1			a	9	<del>در ع</del>	ν <sub>2</sub>	(098 700.)	÷
3.3.8.2	Magnetic Heads		Read/Energize Tape		Oper. T.R.	2.4.1	-		N N	α	<b>6</b> 0	204	(0014100)	
3.3.8.3	Electronics		Control		Oper. T.R.	2.4.1			N	8	e0	) 04	(.015840)	
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PREFLIGHT VERIFICATION OF SUBSYSTEMS

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		Functional Equipment Items	Instrumentation (Limited)	Sensors	Strain	Press. Transducers	Temp. Transducers	Position Sensors	Signal Conditioning	Misc. Conditioning	Elect. Power Source	Batteries - Sil. 2 Inc.		Battery - TVC			_
		Code No.	3.4	3.4.1	3.4.1.1	3.4.1.2	3.4.1.3	3.4.1.4	3.4	3.4.2.1	3.5	3.5.1		3.5.2			

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: 1 & 31

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Propulsion   Main Engine   0   0   0	3.6.1.3	Busses & Circuitry		Power Available	9.99	Use in C/O	2.4.1	×		н	700	-		(.033600)	
Main Engine  Main Engine  Main Engine  1. Igniter  2. Ignition  Exciter  3. Prestart Sole-  noid Vlv.  4. Press Sw.  5. Start Solenoid  6. Start Hc Press.  6. Start Hc Press.  7. Igniter Oxid.  9. Main.  9. Exciter  Apply Power  1.1.7 X 1  8. N 1  8. N 1  8. N 1  8. N 1  8. N 1  8. N 1  9. N 1	<b>0</b> **	Propulsi on												•	
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Igniter         Excite         1.1.7         X         1           Ignition         Energy Avail.         Apply Power         1.1.7         X         1           Exciter         Prestart Sole-         Open/Close         ActPosit.         1.1.7         X         1           Prestart Hc         Open/Close         Act. Posit.         -         X         1           Start Solenoid         Open/Close         Act. Posit.         1.1.7         X         1           Start Hc Press         Open/Close         ActPosit.         -         X         1           Sw.         Igniter Oxid.         Open/Close         ActPosit.         1.1.7         X         1           Supply Vlv.         Sens.         1.1.7         X         1           Supply Vlv.         Sens.         1.1.7         X         1	4.1.1	Main Engine			0						14000	80	.50	000950.	(.034237)
IgnitionEnergy Avail.Apply Power1.1.7X1ExciterPrestart Sole- noid Vlv.Open/CloseActPosit. SensX1Prestart Hc Press Sw.Open/CloseAct. Posit. SensX1Start Solenoid Vlv.Open/CloseActPosit. SensX1Start Hc Press. Start Hc Press.Open/CloseActPosit. SensX1Igniter Oxid. Supply Vlv.Open/CloseActPosit. Sens.1.1.7X1	4.1.1.1	Igniter		Energy Avail.	•	Excite	1.1.7		×	н	0.08	<u>د</u>	8	(0500001)	
Prestart Sole- noid Vlv.  Prestart Sole- noid Vlv.  Prestart Hc Press Sv. Start Solenoid Open/Close Sens. Start Solenoid Open/Close Sens. Start Hc Press. Star	4.1.1.2	Ignition Exciter		Energy Avail.	. :	Apply Power	1.1.7		×	н	5.0	<b>6</b> 0	8	(.000020)	
Prestart Hc Open/Close Act. Posit X 1 Start Solenoid Open/Close Act. Posit. 1.1.7 X 1 Start Hc Press. Open/Close ActPosit X 1 Supply Vlv. Supply Vlv. Sens.	4.1.1.3	Prestart Sole- noid Vlv.		Open/Close		ActPosit. Sens.	1.1.7		×	н	0.11	<b>&amp;</b>	57	(910500.)	
Start Solenoid Open/Close Sens.  Start Hc Press. Open/Close ActPosit X 1 Sw.  Igniter Oxid. Open/Close ActPosit. 1.1.7 X 1 Supply Vlv.	4.1.14	Prestart Hc Press Sw.		Open/Close		Act.Posit. Sens.			×	н_	1.5	<b>6</b> 0	27	(,000684)	
Start Hc Press. Open/Close ActPosit X 1 Sw. Igniter Oxid. Open/Close ActPosit. 1.1.7 X 1 Supply Vlv.	4.1.1.5	Start Solenoid		Open/Close		Act. Posit. Sens.	1.1.7		×	<u>ط</u>	0.11	∞	57	(910500.)	
Igniter Oxid. Open/Close ActPosit. 1.1.7 X 1 Sens.	4.1.1.6	Start Hc Press.		Open/Close		ActPosit. Sens.	ı		×	н	1.5	∞	57	(189000.)	
	4.1.1.7	Igniter Oxid. Supply Vlv.		Open/Close	<del></del>	ActPosit.	1.1.7		<b>×</b>	н	ب	<b>6</b> 0	21	(.000274)	
		·													

PREFLIGHT VENIFICATION OF BUBSYSTEMS

# MODEL 1 & 31

4 + + 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	Attitu. Items	æ																
		KAKT	( 1000001)	1	1	1	•	(.000013)	(:000013)	(.000015)	(.000015)	(.01172)	(,108600.)	(398100.)	(.000012)	(.000002)	(,000028)	
١	Time	£4	8.					5.	'n	٠.	'n	<i>;</i>	57	22	'n	٠.	v.	
	Factor Time	×	8					٧.	r,	2	٧.		<b>&amp;</b>	ဆ	٧.	m	V	
Fail/	10 <sup>6</sup> Hr	γ	ο·τι	ı	t	. 1	1	٠.	٠.	۰.	9.		6.0	1.0	2	<u>н</u>	п	
	Š		1				,	н	н	н	<u>r1</u>	<b>&amp;</b>	<u>a</u>	m	д_	.п	<u></u>	
	Ño.	Test	×					×	×	×	×	×	×	×	×	×	× .	
		Test								<del></del>				···			-	
t,		Locat	1.1.7					1.1.7	1.1.7	1.1.7	1.1.7	1			ı	1.1.7	1.1.7	
Verification Capability		*lethod	ActPosit. Sens.					Act. Posit. Sens	Act. Posit. Sens.	Act. Posit. Sens.	Act. Posit.	·	Fit. only	Fit. only	Eng. Oper only	Visual	Act. Posit. Sens.	
Verifi	*	Risk																
		Parameter	Open/Close		Not feasible to replace	overhaul		Open/Close	Open/Close	Open/Close	Open/Close		Read Press	Read Temp	Read R/M	Crack	Open/Close	
Punct	Frior	Ht.					<i></i>	`										!
	Functional	Equipment Items	Main Fuel S/0 Vlv.	Oxid. Flow Cont. Vlv	Thrust Cont. Valve	Oxidizer Pump	Fuel Pump.	Fuel Pump Disch Cool Down Vlv	Fuel Pump Interstage Cool Dn Vlw	Oxid. Inlet S/0 Valve	Fuel Inlet 8/0 Valve	Sensors/ Transducers	Press	Temp	Speed Transducer	Gimbal Assy	Interstage Bleed & P/R Vlv.	
		Ccde No.	4.1.1.12	ı	ı	ı	1	4.1.1.8	4.1.1.9	4.1.1.10	4.1.1.1	4.1.1.15	4.1.1.15.1 Press	4.1.1.15.2 Temp	4.1.1.15.3 Speed	4.1.1.13	հ.1.1.1	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: 1 & 3I

	Attrib. Items														
	IIART	(,00000;)	426000.	(.000522)	(411000.)	(.000012)	(900000.)	(.000270)	1	1	1	.052359	.004618	(300100.)	(.001065)
	Use Time	5.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			69	69
	Stress Factor K	5	∞	<b>&amp;</b>	80	&	∞	80	80	∞	∞		5	٧.	۶
Fail/	10 <sup>6</sup> Hr	3		10.89	7°2	e.	.13	5.6	100.	.001	100.		9.6	3.0	3.0
	Z Z	1	2	(†)	€	<del>(1</del>	( <del>1</del> )	3	(8)	(2)	(2)			н	н
	Mo. Test	×		×	H	×	×	×	Ħ	×	×				
	Test						,						٠.	×	×
ty	Locat	1.1.7		1.1.7	1.1.7	1.1.7	1.1.7	1.1.1	1.1.1	7.1.1	1.1.7			1.1.7	1.1.1
Verification Capability	Method	Act. Posit. Sens.		Operate/Visual 1.1.7	Operate/Visual 1.1.7	TM Feedback	TM Feedback	Operate	Operate-fravel 1.1.7	Visual	Test Pressure		Verifiable	Tank Leak Test	Tank Leak Test 1.1.7
Verif	Ki sk		0	•									69.3	23.1	23.1
	Parameters	Open/Close		Actuate Script	Actuate Screw	Measure Vel.	Measure Posit.	Feedback Slign.	Travel	Seal Unit.	Relief Setting			Seal Fuel	Seal Oxidiser
Funct	To To Flt.													No.	No
	Functional Equipment Items	Fuel Tank Press Valve	Gimbal Actua- tors (TVC)	Motor Actuators	Magnetic Clutch	Velocity Xducer	Position Xducer	Servo Amplifier	Ball Screw	Bellows	Case Valve	Propulsion Support	Propellant Feed	LH, Feedline Bail Valve	LO2 Feedline Ball Valve
	Code No.	4.1.1.16	4.1.2	4.1.2.1	4.1.2.2	4.1.2.3	4.2.L.4	4.1.2.5	4.1.2.6	4.1.2.7	4.1.2.8	۲° ۶	4.2.1	4.2.1.1	4.2.1.2

PREFLIGHT VERIFICATION OR SUBSYSTEMS

MODEL 1 & 31

		1							•							
Attrib	Items	œ								····	4	· · · · · · · · · · · · · · · · · · ·				
		NAKT	(01,000.)	(.000533)	(100000)		(.000533)	(0000110)	(.00000)	416410.	(.002414)	(969000°)	(.00400.)	(,002414)	(969000-)	(.oo4047)
0.1	Time	E	2 69	e 6	5.6		~&	89	٠ċ	د 69	~ &	2 69	69 69	69	~ S	26
0+ 100 O	Factor Time	M	5	2	ر. د		2	ر.	ı,	\$	<sup>*</sup>	<b>5</b>	2	ر ا	٧	'n
Fail/	10 <sup>6</sup> Hr		2.0	1.5	<b>.</b>		1.5	2.0	<b></b> -		3.1	1.96	5.7	3.4	1.96	5.1
	No.		1	н	н		н	~	н	H	2/4 3.4	н	CI_	7/2	п	cv.
	¥0.		×		×			×	×		×			×	,	
	-	Test		×		-	×					×	×		H	<b>H</b>
25		Locat	1.1.7	1.1.7	1.1.7		1.1.7	1.1.7	1.1.7		1.1.7	2.3.9	1.1.7	1.1.7	23.3.9	1.1.7
Verification Capability		Method	Isol. C/V Test	Valve Posit.	Act. Valve		Valve Posit. Sens.	Isol. C/V Test 1.1.7	Act. Valve		Test for Leaks 1.1.7	Halogen Test	Relief Setg.	Test for Leaks 1.1.7	Halogen Test	Relief Setg
Verifi	><	Risk	15.4	11.5	1		11.5	15.4	1	56.6	16.9	8.4	28.3	16.9	8.4	28.3
		Parameter	Check Flow	Sense Valve Pos.	Open/Close		Sense Valve	Check Flow	Open/Close		Leak to Vent	Leak at Face	Open to Vent	Leak to Vent	Leak at Face	Open to Vent
Funct	rrior	Fit	Yes	Yes	No		Yes	Yes	NO NO		<b>2</b>	න <b>ැ</b>	Yes	No	Yes	Yes
	Functional	Equipment Items	1/2 in. Check Valve	LH2 Feedline Isol. Monitor	Ball Valve Pneu. Actuator		10 Feedline Isol. Monitor	1/2 in. Check Valve	Ball Valve Pneu. Actuat.	Vent (#1)	Isolation Valves - LH2	Tug/Orbiter Ftg III	elief LH2	Isolation Valves LO <sub>2</sub>	L	Vent & Relief Valves LO <sub>2</sub>
		Code No.	4.2.1.3	հ.2.1.4	4.2.1.5	4.2.1.6	4.2.1.7	4.2.1.8	4.2.1.9	4.2.2	4.2.2.1	. 4.2.2.2	4.2.2.3	դ.ջ.ջ. դ	4.2.2.5	2.2.6

PREFLIGHT VERIFICATION OF SUBSYSTEMS

NODEL 1 & 31

		Funct		Verifi	Verification Capability	\$				Pa11/				
	Functional	Prior		•				, M			Stress Use Factor Time	Time		Attrib. Items
Code No.	O BES		Parameter	Risk	Method	Locat	Test	Test			×	H	KAKT	æ
4.2.3	Fill & Drain			801		-			τ		٠.		.007335	-
4.2.3.1	F&D Valve - IH2 Yes		Open/Close	34.5	Fill Cycle	2.4.3	×		m	3.4	ıv.	%	(.003621)	
4.2.3.2	Full Valve - 102 Yes		Open/Close	æ.5 €.5	Fill Cycle	2.4.3	×		m	3.4	5	ر و و	(.003621)	
4.2.3.3	Disconnect LH2	Yes	Seal to Orb.	10.3	Halogen Test	2.3.9	×			1.96	Φ.	QI_	(100000.)	
4.2.3.4	Disconnect LO2	Yes	Seal to Orb.	20.7	Halogen Test	2.3.9	×		N	1.96	Φ	N.	(.000062)	
4.2.4	Pneumatic			100					н		•		.017380	
4.2.4.1	S/O Valve Modules	Part.	Part. Open/Close	001	Actuate Valves 1.1.7	1.1.7	- <del></del> -		22	2.0	<b>ا</b>	ន្ទ	(.017380)	
4.2.5	Propellant Utilization			100					-				465400.	
4.2.5.1	LH, Capac. Probe	Yes	Quantity Meas.	R	Monitor Fill	2.4.3	×		н	1.0	<b>.</b>	~8	(895000.)	
4.2.5.2	LO, Capac. Probe	Yes	quantity Mess.	ጽ	Monitor Fill	2.4.3	×		н	1.0	€	8,5	(.000568)	
4.2.5.3	Prop. Utiliz Assy	Mo	Control Flow	0	Calib.	1.1.7		×	н	6.2	<b>&amp;</b>	69	(.003422)	
4.2.5.4	Capac. Probe Attach.	Yes	Seal Tank	1	Hold Press.	1.1.7	×		α.	20.	۲.	. 69	(9800000.)	
4.2.6	Pressurization			6.66					н				.004118	
4.2.6.1	Tanks He	Yes	Leakage	2.4	Press Decay	2.4.2	×		<u>۷</u>	0.05	ر.	26	(.000099)	
4.2.6.2	Regulator	Yes	Regulated Press.	1,8.0	Press. Txdcr	2.4.2	×	· · · · · ·	α	2.5	is .	10	.001975)	

PREFLIGHT VERIFICATION OF SUBSYSTEMS
NODEL: 1 & 31

		Funct		Verifi	Verification Capability	ţ,				Fail/		3		Attrib
Code No.	Functional Equipment Items	Prior To Fit	Parameter	Kisk	Method	Locat	Tcat	Mo.		10 <sup>6</sup> Hr F	Factor Tim	Time	NAKT	Items R
4.2.6.3	Shut Off	Yes	Leakage	19.2	Press. Decay	2.4.2	×		~	1.0	2	28	(.000790)	
4.2.6.4		Yes	Leakage	4.0	He Loss	2.4.2	×		<u>.</u>	0.05	'n	- 69 69	(300001)	
4.2.6.5	Relief (Burst)	Yes	Leakage	1.0	Press. Decay	2.4.2	×			0.10	<u></u>	0169	(0,00000.)	
4.2.6.6	Fill Adapter	Yes	Leak-Interface	0.5	Halogen Test	2.3.9	×		<u>-</u> -	0.05	'n	<u>)</u>	(.000020)	
4.2.6.7	IH Tank Press.	Yes	Open/Close	8.6	Press. Avail.	1.1.7	×	<del> </del>		1.0	۲.	) 89 89	(.000355)	
4.2.6.8	LH2 Tank Press. Yes	Yes	Flow Rate	6.0	Press. Avail.	2.4.3	×			01.0	v.	2 69	(9€0000-)	•
4.2.6.9	Eng. Press. Orifice (GH)	No	Flow Rate		Calib.	MF6		H	н	01.0	5		(.000001)	
4.2.6.10	Eng. Press.	No No	Open/Close	1:0	Monitor Posit. 1.1.7	1.1.7		×	<u>-</u>	o.	rv.	.*.	(.00003)	
4.2.6.11	LO2 Tank Press.	Yes	Open/Close	17.2	Press. Avail.	2.4.3	×		N N	1.0	2	69	(.000710)	
4.2.6.12	102 Tank Press. Yes Orifice	Yes	Flow Rate	7-1	Press. Avail.	2.4.3	×	,	N .	0.10	2	69	(.000071)	
4.3	ACPS Engine			0					ے				.00/09/ 0053h	
4.3.1	ACPS Module					,		,	(75)	çç	۶	2	( 000614)	
4.3.1.1	R-30 Engine	S S	Flow Rate		Calib.	71.12		<b>&lt;</b>	OT .	٠ ۲	, 1		(09000)	
4.3.1.2	Thrustor Isolation Va	No	Open/Close	:	Monitor	21.1.1		H	(10)	<b>.</b>	^		(nokomo)	
4.3.1.3	Thrustor Cont.	No	Open/Close	<del>,</del>	Monitor	1.1.12		×	0:1 (91)	1:0	<sub>آ</sub>	12	(096000')	
		-			,									, ,

PREFLIGHT VERIFICATION OF SUBSTSTEMS

NODEL: 1 & 3 I

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10 HE	Ω ≍	<b>P</b> 4	No. Test Test	No.	No. Test Test	Locat Test Test	Method Locat Test Test	Hisk Method Locat Test Test
	i .					100	100	100
1.0		m	<u>к</u>		×	2.1.7 X	2.1.7 X	Tank Press. 2.1.7 X
0.9	<b>€</b>	(3)	×		×	2.4.2 X	2.4.2 X	Tank Press. 2.4.2 X
0.10	2	(10	<b>*</b>		<b>×</b>	2.4.2 X	2.4.2 X	Tank Press. 2.4.2 X
1.0	9	(10	×		×	2.4.2 X	2.4.2 X	GN2 Press. 2.4.2 X
0.05	$\Box$	(T)	×		×	2.4.2 X	2.4.2 X	- Monitor Fill 2.4.2 X
1.0	_	(T)	×		×	2.1.7 X	2.1.7 X	Monitor Fill 2.1.7 X
0.05	a	3				2.1.7 X	2.1.7 X	- Monitor Fill 2.1.7 X
0.10	$\Xi$	(T) ×	×		×	x x	x x	Flight Date 1.1.7 X
1.0	⊋•	€.	×	×		×	×	Monitor Press. 2.4.2 X
2.5		<u> </u>	×		×	2.1.7 X	2.1.7 X	Software 2.1.7 X
					-			

Nev. 8-16-73 Option 1-1 By Downs Date 8-14-73

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	Repair Subassy	H	<u> </u>			****	 		·	
	Rits-Debot Rebeir Subsessy	0.005	(0.005)	(0.03)	(0.02)	99999		• • •		
ance	Sberes ObS Snpessy	8.1	0 H -	•	สส	aadaa	·	-		
Maintenance	Repair Component		× ×	. × ×	××	×				
11	gnpsask Keplace						<del>-</del>			:-
Level	Subessy Failed/ 5 Flts	0.05	0.05	0.10	0.25				o* •	
	Subassy Failed/ 100 Fits	ч	а	Q	20.00			****		****
	Component Float Stock (OFS)							•		
e e	Component Initial Stock	• • •	0 -	10 0	00	00000		•	<b>V</b>	
nenc	Repair Tug	×	× ×	× ×	××	×		7		
Waintenance	Replace Comp/LRU	×	<b>&gt;</b> :			***				
Level I	Petlures Per ₹ Flts	0.1	0.1	}	!	0.03	<b>.</b>			
	Failures Per 100 Flts	e e	a a	,		40004				
	Number Per Tug	183	-93-5	3373	-33·		i			
	evel 8			sce Kit				y.		
	- Subassembly La - Component Leve - Assembly Leve (al Equipment (emponent, Subassy Structure	Įt.	· •	Orbiter Interfe	n Sandwich					
	Functional Equipment  (Assembly, Component, Subass;  Structure	Structure Fuel Tank Access Gaskets Structure Repair Kit	Oxidizer Tank Access Gaskets Structure Repair Kit Body Structure	Access Panels and Orbiter Interfe Thrust Structure Repair Kit	Meteoroid Shield Repair Kit Aluminum Sandwich Repair Kit FBCLS	rayload Docking Latches Latch Trigger Retract Cylinder Plumbing (Kit)				
	Code Code	1. 1.1. 1.1.2	11.0.1. 13.0.1. 13.0.1.	1.3.2	1.5.2	11.66.2 11.66.3 11.66.3 11.66.3				

TUG SPARES AMALYSIS - M ENGINEERING

Date 3-14-73

Downs

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Option 1-2

roded ta a N ដ Repair Subassy Kits-Debot Rebett Rapess 0.00 0.25 Speres SãO **Yeasou**2 Maintenanc  $\neg$ Component ××× итебэй. Subsesy Level II керласе 2 Life Leffeq\ Supersh TOO LIFE Leffed\ Snpessh Component Float Stock (OPS) Component Initial Stock Repetr Tug × × Comb\run gebjece ×× esta s 0.15 194 Patlures 700 Effe Set 0.00 0.05 0.06 Failures Per Tug 448 *Humber* Functional Equipment (Assembly, Component, Subassy) Subessembly Level E Component Level 7 Assembly Level 6 Thermal Control Thermal Control Tank Paint Insulation Purge Liner Repair Kit Plumbing Code Code જં

0-19

	toged ta		<del></del>	· · · · · · · · · · · · · · · · · · ·	<b>*</b>	7	
	Repetr Subesey	***	*****		₹,		
	Kits-Depot				: <b>:</b>		
	Subsesy	4.0 4.0	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	લાં લા લાજ વ			
	Spares	H2 0	NHOKEUH	80484	26		
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Maintenance	Repetr Component				100 mg		
11 M	Subesey		<del></del>		, s**		
	нерласе	HHH		****	,		
Level	≥ LT£#				. <b>**</b>		,
	Subassy Failed/	0.05 0.17 0.01		0.07 0.03 0.06 0.05			
	TOO ETES	000		00000	*	<del></del>	
	Estled/	0.91 3.53 2.23		8 ሕ ຊ ວ ຊ	√. et		
	(940) ¥201S	o m o		<u> </u>			
	Component Float	H					' ·
	Component Initial Stock	н	0444000	2	**		
Doe	Repair Tug			<u> </u>	**		
ten	Comp/LAU			8-15-73 x		· · · · · · · · · · · · · · · · · · ·	
Maintenance	Вердасе	×	*****		ş/s		·
н	S Plts	<b>m</b>		ute.	<b>)</b>	· ·	
Level	Pailures	0.23	0.00	Computer			•
	TOO ETES			<b>A</b>	t.		
	Feilures Per	55	828288	led with _ 5.71			
		'	2.37 2.91 0.36 0.36 1.82	led w			
	Number Per Tug		122224 12224 1224 1224 1224 1224 1224 1	Sance.			
		17555	2 4 4 4 4 4 4	<u>0000001 B</u>	*		
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	T VE VE VE VE VE VE VE VE VE VE VE VE VE			7			•
	Submasembly Lave Component Lave Assembly Lavel al Equipment omponent, Subm		( <del>)</del>	atr.			
	Market Squit;		(a) (b) (c) (c) (c) (c) (c) (c) (c) (c) (c) (c	d Co onte	r. *		
	Subasse Compone Assembl nal Equi Componen			a a			
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	Subassembly Component Lev Assembly Lev Functional Equipment embly, Component, Sul	ess(	ol U	ox) igat igat ra ra roui and			
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		Men Men uter rel Mis	H LHESTER G OFT	Asset Buller Bul			- :
		Avionics Data Management Computer Central Processor Winit Misc (Box)	Bus Interface Unit (BIU) Power Control Unit (PCU) Discrete Command Unit (PCU) Remote Multiplex Unit (RWU) Data Interface Unit (DIU) Signal Conditioning Unit (SCU) DCU System Control Unit	PC Board A PC Board B Unit Misc (Box) Guidance Navigation, and Control INU Opro Assembly Accelerometers Sensor Electronics Power Supply and Electronics Housing and Coolent			
	e e		В В В В В В В В В В В В В В В В В В В	наро <b>поч</b> ой	<u></u>	· · · · · · · · · · · · · · · · · · ·	
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	္ ode	33.1.1.2					
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Option 1-4 By Downs Nate 3-14-73

TUG SPARES ANALYSIS - M ENGINEERING

	Repair Subasey	<b>*</b> *	их би ни нии иби	
	Kits-Debot Rebeit Enpesel	0.0	0.3 0.10 0.10 0.10 0.10 0.10 0.10 0.10	
Brce	Suberes Ops Speres	ннн		
Maintenance	Repetr Component			
H	Subsesy Replace	×××	× ×× ××	
Level	Submeny Submens	0.08	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	
	Subessy Feiled/ 100 Fits	1.60 0.32	0.22 0.18 1.94 0.35 0.35 0.04 0.04 1.58	
	Component Float Stock (OPS)			
	formponent Mack Stock	0	001 0 00 01	
ance.	Repair Tug			
Maintenance	Replace Comp/LRU	×	*** * ** **	
Level I M	Ler	0.10	0.01 0.02 0.03 0.04 0.04	
.3	TOO Effe Per Per	1.92	0.12 2.15 2.15 0.17 0.35 2.16	
	Number Per Tug	(2)	# T T T T T T T T T T T T T T T T T T T	
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	Sode 3	3.2.2 3.2.2.1 3.2.2.2	പ്രൂപ്പ്പ് പ്രൂപ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ് പ്രൂപ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ്പ് പ്രൂപ് പ്രവ്വ് പ്രൂപ് പ്രൂപ് പ്രൂപ് പ്രവ്വ് പ്രൂപ് പ്രൂപ് പ്രൂപ് പ്രവ്വ് പ്രൂപ് പ്രവ്വ് പ്രൂപ് പ്രവ്വ് പ്രൂപ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ് പ്രവ്വ്	

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	Znpessk Rebrece		<u></u>				· · · · · · · · · · · · · · · · · · ·	•	<u>-</u>	
	Subesey Falled/ 5 Fits	<u>,</u>	<u>.</u>	Quantit es			₩.		<del></del> -	
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	Component Float Stock (OPS)			dom r hedul			•			
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	Replace Comp/LRU	×××		C Abo			i j			
	Fellures Per 5 Fits	0.001 0.004 0.021 0.064	0.005	fter Flt fter Flt	0.01 0.07 0.17					
•	Feilures Fer	1.80 0.02 0.08 1.28 0.84	0.03	Replace A O Replace A	0.27 1.41 3.36					
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	Subassembly Level 8 Component Level 7 Assembly Level 6 and Equipment Component, Subassy)			-						:
	Subassembly Leve Component Leve Assembly Level (Assembly, Component, Subs Avionics (Cont)	Instrumentation Sensors Strain Press Transducers Position Sensors Signal Conditioning Grant-reserventers	Electrical Power Source Batteries - Silicon Zinc	Battery - TUC	Power Distribution Motor Driven Switches Relays Busses and Circuitry (Kit.)					
	Code Jode 3.		3.5.1	3.5.2	3.6.1 3.6.2 3.6.3					

TUG SPARES ANALYSIS + N ENGINEERING

Ogilon 1-6 By Downs Date 8-14-73

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Maintenance	Repetr JaenogmoD		
12	Subsesy Replace	*****	
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	TOO EIFS Esting	· <b>9</b>	
	Component Float Stock (OPS)	ngi ne	
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nance	Repair Tug		
Maintenance	Replace	XXXXXXX XX I	
Level I	Pallures Per 5 Fite	0.28 X 0.025 X 0.003 X 0.003 X 0.003 X 0.001 X 0.001 X 0.001 X 0.006 X	
	TOO LITE LetjmLes	5.60 0.005 0.002 0.002 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001	
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	Component Level 8  Assembly Level 6  Functional Equipment (Assembly, Component, Subsesy)  Propulsion	Engine Igniton Excitur Frestart Solenoid Valve Frestart Solenoid Valve Start Solenoid Valve Start Solenoid Valve Start Solenoid Valve Start Solenoid Valve Fuel Pump Discharge Cool Down Valve Fuel Pump Discharge Cool Down Valve Fuel Pump Discharge Cool Down Valve Fuel Inlet Shutoff Valve Main Fuel Shutoff Valve Galbal Assembly Glabal Assembly Glabal Assembly Fresture Speed Fresture Gowidizer Flow Control Valve Twust Control Valve Thrust Control Valve Oxidizer Flow Control Valve The Tamperature Oxidizer Pump Fuel Fuel Oxidizer Pump	
	e code	100000000000000000000000000000000000000	······································
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Rev. 8-16-73 Date 8-15-73

By Downs

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	Repair Subassy at Depot	** \$ \$ * * \$ \$	** \$ \$				
	Subessy Repair Kits-Depot	0.3 0.015 0.01 0.04 0.2	0.15 0.15 0.60 0.5	•			
e o	Subessy OPS Spares	nn000n0n0	нне				
Maintenance	Repair Component						
II Yah	grpessk gebjece	× ×				<del></del>	
Level .	Subeasy Failed/ 5 Fits	0.003				<del>.</del>	
	Subessy Feiled/ Subessy	0.052 6.011 0.001 0.001					
	Component Float Stock (OPS)				-		
_	Component Initial Stock	0	0000				
Maintenance	Repair Tug						
Maint	Replace UMJ/LMU	×	***				
Level I	Feilures Per 5 Pits	0.005	0.023 0.005 0.007 0.007				
	Feilures Per 100 Fits	0.00	(0.46) 0.11 0.11 0.14				
	Number Per Tug	000EEEE	(5)				
	Component Level 7  Component Level 7  tional Equipment Component, Subassembly)  Engine (Cont)	Gimbal Actuators Motor Actuators Magnetic Clutch Velocity Transducer Position Transducer Servo Amplifier Ball Screw Rellows Case Valve	Main Engine Support Propellant Feed IM2 Feedline Ball Valve IO2 Feedline Ball Valve I/2-in. Check Valve Feedline Isolation Monitor				
	Code	83-4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4	2 4 4 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7				÷

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Cpt1.m 1-7

By Down Date 5-16-73

Ĺ	Repair Subassy	*****	***	<b>×</b>	×××	
	Kits-Debot Rebsir Ropssay	0.30 0.13 0.5 0.30 0.13	0.50 0.50 0.01 0.02	2.26	0.08 0.08 0.52 0.02	
Maintenance	Subares OPS Spares	апана	ааа		пппп	
II Mai	Kepetr					
Level	Subasey Replace					
1	Submesy Failed/ 5 Fits					
	Submesy Failed/ 100 Fits		·	· · · · · · · · · · · · · · · · · · ·		
	Component Float Stock (CPS)					
da .	Component Initial Stock	00000	0000	0	0000	
Maintenance	Repair Tug					
	Replace Comp/LRU	*****	***	×	****	
Level I	Pedlures Per 5 Flts	0.012 0.003 0.020 0.012 0.003	0.018 0.018 0.001	0.087	0.003 0.003 0.020 0.001	
	Fellures Per Too Fits	1.43 0.24 0.07 0.80 0.07 0.07	0.73 0.36 0.003 0.003	1.74	0.52 0.06 0.06 0.39	
	Number Per Tug	-55656	18838	(22)	-33 <b>3</b> 8	
Code - 1.1.1.1 Subassembly Level 8	Component Level 7	Vent Isolation Valves LH2 Tug Orbiter Fitting Vent and Relief Valves Isolation Valves LO2 Tug Orbiter Fitting LO2 Vent and Relief Valves LO2	Fill and Drain (and Abort) Valve LM2 Valve LO2 Disconnect LM2 Disconnect LO2	Pneumatic Control Valve Modules	Propellant Utilization LH2 Capacity Probe LO2 Capacity Probe Propellant Utilization Assembly Capacity Probe Attach/Gaskets	
	Code	1000200 0000000 0000000 0000000		4.2.4	4.2.5.1 4.2.5.2 4.2.5.3 4.2.5.3	

	Repair Subassy at Depot	×××× 4× 4	×××	×××××××			
	Kits-Debor Bebsir Snpssan	0.02 0.27 0.03 0.02 0.03	0.12 0.13 0.13	0.16 0.05 0.005 0.05 0.05	,		,
ice	Spares Ops Subassy	анноння	апап	атаааааа			
Maintenance	Repart Component						12.00
II Mai	Subassy Replace		×××				
Level	Submesy Falled/ 5 Fits		0.004			· · · · · · · · · · · · · · · · · · ·	
	Subessy Failed/ 100 Fits		0.06 0.10 0.10				
	Component Ficat Stock (UPS)						**
	Component Initial Stock	000000	0000	0 000000			
Brice	Repair Tug				* K		
Anintenance	Replace Comp/LRU	****	*	* *****			
Level I A	Feilures Per 5 Fits	0.001 0.01 1	0.013	0.005			
13	100 Fits Per Per	0.01 0.02 0.02 0.024 0.002 0.004 0.002	0.25	0.12 0.034 0.004 0.04 0.04			,
	Number Per Tug	333333333333333333333333333333333333333	4 (16) (16) (16)	<b>5666666</b> @	š.		
θ. Ε.	o mbly)						
Code - 1 1 1 1 Subassembly Lev	Component Level Assembly Level ional Equipment Component, Subasse Engine Support	Pressurization He Tanks He Regulator Shutoff Valves-Solenoid Plenum Relief Valve-Burst Fill Adapter Tank Pressurization Orifice	ACPS Engine ACPS Module R-30 Engine Thrustor Isolation Valve Thrustor Control Valve	ACPS Engine Support Tank Bladder Relief Valve Fill Valve GW2 Fill Fitting GW2 Fill Fitting N2H Fill Fitting N2H Fill Fitting N2H Module Isolation Valve			
	Cod <b>e</b>		4.3 4.3.1. 4.3.1.2 4.3.1.2	14444444 110647444 10647444	Ŕ		

[E	TOTAL DEPOT SPANES IN EES	9	9.00g	0.000ê	0.0003	0.0046	0.0018	9.0000		0.0002	~	*	 		
*	TOTAL DEPOT REPAIR KITS IN EES	C125D								0.0002			 		
2	TOTAL DEPOT REPAIR KITS IN EQUIV BURASEYS	Q.		0.010	0.010	6.7	0.03	₹ 0		90.0			 		
=	DEPOT REPAIR RITS IN FOUIV BURABYS	ĝ		0.005	0.005	0.05	0.03	9.00	0.05	0.0000 0.0000 0.00000					
13	TOTAL COER SPARES IN EES	60	0.206	0.130	0.051	0.012	90.00	0.003		9.0					 *\ <u>`</u>
2	OPER SUBASSY SPARES IN EES	105713		0.0002	0.0001	0.0046	0.005t	0.0001		0.0007					
18	TOTAL OPER SPARES SUBASSYS	1082		0.002	0.005	0.07	0.10	9.00		0.320			 		
12	OPER SPARES SUBASEYS	â		0.00	0.00	0.0 8.0	0.10	0.002	0.005	00000 8888 11		<u>.</u>			
2	OPER CORP SPARES IN ESS	P-C-80		0.30	o.3	01.0	0.10	0:10		0.10					
1.2	OPER SPARES COMPO- NENTS	Q								· · · · · · · · · · · · · · · · · · ·			 		
٤	TOTAL MITIAL SPARES IN EES	13	٥												
2	S33 NI S3VV45 ABVOTS ABVOTS	C12.51													
•	TOTAL INITIAL SPARES SUBABBYS	183		•										· · · · · · · · · · · · · · · · · · ·	
•	SASSEMBLE STRANGES STATES	ā											 		
•	AVC SUBABEV COST AS FRACTION OF ASSV COST	ě		0.080	0.032	0.065		0.015		0.0022					
•	MITTAL COMP SPARES NI ESS*	18 C			,								 		
•	MENTS SOMES SOMES WENTS	ā											 		
•	SAAR COST AS FRACTION OF ASSY	σ		[0.48]	(61.9)	[0.13]	[0.06]	[0.03]		[0.0 <del>]</del>					
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~	27)1 1836 1836(14)			<b>-23</b> ∃	1 <u>83</u>	-33	<del>-</del> 3	<del>1</del> 3	3	назанн			 		
-	3 <b>00</b> 0		1.0	1.1	1.2.1	1.3 1.3.1 1.3.2	1.4.1	1.5.1	1.5.2	1.6.2 1.6.2 1.6.3 1.6.4					
	IDENTIFICATION		Structure	Fuel Tank Access Gaskets Structure Repair Kit	Oxidizer Tank Access Gaskets Structure Repair Kit	Body Structure Paint Access Cover Panels	Thrust Structure Repair Kit	Meteoroid Shield Repair Kit - Aluminum	nandwich Repair Kit - FBCLS	Payload Docking Latches Latch Trigger Latct Cylinder Plumbing Kit Frame Tube					

Options 1 and 31

Options 1 and 31

	TOTAL DEPOT SPANES IN EES	9	0.262	o.23	0.012			
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	DEPOT REPAIR KITS IN EQUIV RUBASEYS	ğ			·			
	TOTAL OPER SPARES IN EES	0	0.210	0.10	0.11			
	OPER SUBASEY SPARES IN EES	C1250	Ŭ		- <del></del>			<b>1</b>
	TOTAL OPER SPARES BLBASSYS	Š						
	OPER SPARES SUBASSYS	ĝ				***		
-	OPER COMP SPARES IN ESS	PC-SO		0.1	0.00		· .:	
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1	MITIAL SUBASSY SPARES IN EES	C125i						*!.
	TOTAL INITIAL SPARES SLEASEVS	Ē					····	- A
	MITIAL PARES SUBASSYS	ă				, <b>*</b>		
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	NUMBER PER TUG			-		, A		
	<b>300</b> €		2.0	2.1		Tag.		
	PENTIFICATION		Thermal Control	Tank Paint	Insulation Puge Liner Repair Kit Plumbing Valves			SE 1973 H.A. IMPRISAY SHILL IV. ALBERTA LAND STORY OF THE

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Options 1 and -1

Substitute   Sub	State   Stat
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3 0.03 19.1	0.03

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TOTAL DEPOT SPARES IN EES	8	0.43				
TOTAL DEPOT REPAIR KITS IN EES	C125D	0.31	0.12			
TOTAL OEPOT MEPAIR KITS IN EQUIV	ŶS.	7.1	7.2			
DEPOT REPAIR KITS NO EQUIV SURASSYS	á	000.00 1	2.0			* 1
TOTAL OPEN SPARES IN EES	0	0.019				
OPER SUBASEV SPARES IN FES	C1250	0.28)	0.10			
TOTAL OPER SPARES SUBASEVS	ĝ.	#	C)			
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ONE NAMES S	P. C-80	(0.09)	8.:			de
OPER SPARES COMPO- NENTS	ē		н .			
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TOTAL INITIAL SI	181					**
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AVG SUBASEY H COST AS F RACTION OF ASSY SU	ž.	0.0 <del>44</del>	0.050	And the	ž.	
SPARES FR.	3-C-81	0.12)	o o		1. ***	
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OENTIFICATION		Avionics (Cont'd) G, N & C I'Mi Gyro Assy Accelerometers Sensor Electronics Electronics	Housing & Coolant Star Sensor Sensor Stabilizer Drive	* 1		

Options 1 and J

Options 1 and 1																			Ž	Avionize 3	- 45 S4
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IDENTIFICATION	<b>30</b> 00	NUMBER PER TUG	0004 0004 0004 0004 0004 0004	SOME SPANE COST AS PRACTION OF ASSY COST	4 0 E	₹ \$ \$2 \$2	AVG SUBASSY COST AS FRACTION OF ASSY COST	INITIAL INITIAL SPARES SPARES SUBASSIVE SUBASEVS		SUBASSY SPARES IN EES	TOTAL SI INITIAL SI SPARES IN EES D	OPER SPARES COMPO NENTS	OPER COMP SPARES IN ESS SU	OPER T	TOTAL OPER SPARES SUBASSYS	OPER SUBASSY SPARES IN EES	TOTAL CHE A SPARES IN EES	S SASSVENS AMO3 WITZ IN WITZ IN	TOTAL DEPOT REPAIR KITS IN EQUIV SUBASSYS	TOTAL DEPOT REPAIR KITS IN EES	TOTAL DEPOT SPARES IN EES
				σ	is	R-Cp-Si	Ç J	á	ñ	1831	- -3	Š	P-C+50;	ŝ	1.50	C1250.	EO.	93	-O\$17	C1ZSD:	60
Communications	3.3			[0.53]		0.189)		-		(0)	0.189)		(0)			(0.442)	(0.442)			0.566)	38.3
Antenna Multíplexer	3.3.1	<i>a</i> -	0.225	0.05 U.05	00		· · ·			<u> </u>	3			ан		0.030	55.5	0.3		0.003	
Power Amp TWT Circuitry	3.3.3 3.3.3.3 4.3.3.3	<b>-€</b> 3	8.0	0.11	-i	660.0	0.022							- 67 -	m	0.099		0.6 0.3	9.3	0.205	
Transponder PC Board Component Circuits	3.3.4 3.3.4.1 3.3.4.2	~£@	0.45	0.11	0		0.018		<del></del>					440		0.050		0.1 0.1	0.5	600.0	
Command Decoder	3.3.5	~	0.45	0.11	٥									O.		0.099		0.3		0.015	
Processor PC Boards Circuitry	3.3.6 3.3.6.2 3.6.2 6.22	1861 E611	8.0	0.20	0	·	0.067		<del></del> -		<del></del>					0.180		4 6	9.0	0.040	
Command Encoder	3.3.7	н	%.	0.11	٥			-						٦		0.099		1.0		0.099	
Tape Recorders Tape Drive Mechanical Magnetic Heads Electronics	6.6.6.6. 6.6.6.6.6. 6.6.6.6.6.6.	~ଉଉଉ	- 0.45	0.20	-	0.090	0.033								ο,	0.066		2.0	3.6	0.045	
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DENTIFICATION	2005	NUMBER PER TUG	SPARE COST COMP SHIPSET COST	SPARE COST AS FRACTION OF ASSY COST	SPARES COMPO NENTS	S COMP COMP SPARES IN ESS*	AVG SUBASEY COST AS S FRACTION OF ASSY COST	SPARES SPARES N SUBASSYS	TOTAL INITIAL SPARES SUBASSYS	MITIAL SUBASSY SPARES IN EES	TOTAL INITIAL SPARES IN EES	SPARES COMPO NENTS	OPER COMP SPARES IN ESS	OPER SPARES SUBASSYS	TOTAL OPER SPARES SUBASEYS	OPER BUBASSY SPARES IN EES	TOTAL OPER SPARES IN EES	F € ₹ ≥ \$	TOTAL DEPOT MEPAIR KITS IN EQUIV	1 525 = E	TOTAL DEPOT SPARES IN EES
			2	3	รั้	R-C-Sh		ā	įŠ	CLESI	ū	ğ	A-C+30,	ŝ	1.50,	C1250,	2	á	zSO.		2
Instrumentation	3 ==			[0.06]		(0)				0	0		(0)			+ <del>-</del> -	(0.313)			(0.005)	0.005
Sersors Strain Pressure Transducers Temporature Transducers Position Sensors	3.4.1 3.4.1.2 3.4.1.2 3.4.1.3 3.4.1.3	(S) (S) (S) (S) (S) (S) (S) (S) (S) (S)	0.90	0.45	0+		0.005							~222	83	0.175	0.019	1135	0.7	٥.٥٢٠	
Signal Conditioning 3 Signal Conditioning 3 Units Circuitry 3	3.4.2	(65)	8.	0.45			0.007							8	&	0.138		0.1		0.001	
Elect. Power Source  Batteries - Ag/Zn  Batteries - TVC	3.5.2	484	0.45	[0.01] 0.85 0.15		,		<del></del>			0			0.4		(0.288) 0.153 0.135	0.003				0
Power Distribution  Motor-Driven Switches  Relays  Busses & Circuitry Kit	3.6.6. 6.6.6. 6.6.6.1 7.6.6.1	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	0.08 0.90 0.90	(0.03 0.03 0.03 0.03	•••	······································					٥			- m		0.045	0.083	0.0.1 0.00 0.00		(0.138) 0.03 0.032 0.032	0.138
	*: *:		j		*			è	ž.		À	<b>*</b>	S. C.	· · · · · · · · · · · · · · · · · · ·	*	•	•			5	*
FOURVALENT BRIPSETS OF THE ASSEMBI VILEVEL 6	SSEABLYIL												**************************************	17	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			n i			

Propulsion P.1 of 5

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	-	-	-	•	-	_	-	-	+	2	=	=	-	<u>.</u>	-	†	T				T	
IDENTIFICATION	3000	15 A 20 A 20 A 20 A 20 A 20 A 20 A 20 A 2	2004 2004 2004 2004 2004 2004 2004 2004	SPARE SPARE COST AS FRACTION OF ASSV	INITIAL SPARES COMPO NENTS	MESS WESS	AVG COST AS PRACTION OF ASS	WANTS S	TOTAL MUTIAL SPARES LEASYS	BUTTAL SUBASEY SPANES IN EES	TOTAL MNTIAL SPANES IN EES	OPER SPARES COMPO NENTS	W WES	OPER SPARES BURASEYS	TOTAL OPEN SPANES	OFFR SUBASEV SPARES IN FES	TOTAL OPEN SPANES IN EES	MEPAIR KITS IN EQUIV SUBAREYS	DEPOT REPAIR KITS N EQUIV	TOTAL DEPOT REPAIR R EES	TOTAL DEPOT SPARES IN EES	
			8 «	σ	5	\$ C.	. Š	ā	ñ	C1ZSi	Ξ	ã	og og	٩	Õ	01210	2	ĝ	ĝ	CIESO	2	Note 1
Propulsion	0.4										0.162						0.419				0.061	)
Main Engine Engine	4.1		8	[0.19]		0.855	0.0413			0	0.855)				15	0.620	(0.647)		8.3	0.122	(c.158)	
Prof to a	111			<u> </u>		<u>`</u>												0.0				
1 Valve	1111										******							0 0 0 0			*	
	4.1.1.5	4,			· · · · · · · · · · · · · · · · · · ·					•		<del></del>		44				0.8				
Switch Switch Teniter Oxid Supply	1111																	0.1				
Valve Fuel Pump Disch. Cool	4.1.1.8													. н				0.05				
Down Valve P. P. Interstage Cool	4.1.1.9	н												-				0.05				
Down Valve Oxidizer Inlet S/0	4.1.1.	٦												-				0.05				
Valve Puel Inlet 8/0 Valve	10 1.1.4	-												п				0.05				
Main Fuel 8/0 Valve	п <u>т</u>	٦					· ·							7				9.03				
Gimbal Assv	21.1	-												٦				0.01				
Interstage Bleed & PR	13	-												-				0.1				
Valve Sensors/Transducers	17. 1.1.	60					(0.0052)								€	0.021			(9.9)	0.034		
Pressure	15 1.1.1.	3												CI.				4.5				
Temperature	15.1	3												7				1.0				
Speed	15.2	3												٦				0.1				
Fuel Tank Pressure	15.3 16.1.1 16	н												7				0.1				
4.1.1.17 - 4.1.1.21 No Maintenance Possible	Maintena	ince Poss	tble																			
······																						
				_							<u></u>											
																						_
Note 1 Main Engine Omitted for Depot.	itted for	Pepot.									_]											_
T 40 ST 3000 ENT 600 FT	ME ASSESSED	PETTS OF THE ASSEMBLY (LEVEL 6)																				

Options 1 and 31

Propulsion P. 2 of 5

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1	IDENTIFICATION	<b>30</b> 000	TO SUCCESSION OF THE PROPERTY		SPARE COST AS FRACTION OF ASSY	HUITIAL SPARES COMPO NENTS		AVG SUBASEV COST AS RACTION OF ASSY COST	MITTAL SPARES LUBASSYSIS		MHTIAL SUBASSY SPARES IN EES		OPER SPARES COMPO NENTS				OPER SUBASSY SPARES IN EES		DEPOT REPAIR KITS IN EQUIV SUBASSYS	TOTAL DEPOT REPAIR KITS IN EQUIV SUBASSYS		TOTAL DEPOT SPARES IN EES
1.12 1 (4) 0.000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				•	ū	-		C)	ā	Ř	C1 XSii	13	Ŝ	R-C+SO;	ŝ	ŞŞ	C) 250,	g G	Ğ	.SD.	C1250,	8
	Gimbal Actuators Motor Actuators Motor Actuators Magnetic Clutch Valocity Transducer Position Transducer Ball ocrew Ball ocrew Ballows Case Valve	2 1 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1		জ ব ০	60	0		0.0019				О		0.023	000000	m	0.0058		00.00 00.00 00.00 00.00 00.00		0.0018	
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Options 1 and M

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Propulsion P. 5 of 5

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IDENTIFICATION	<b>8</b>	NUMBER PER TUG	SAME THE SOUTH	SPARE COST AS FRACTION OF ASSY	MITTAL SPARES COMPO NENTS	MITIAL COUP SPAIRES IN ESS	BUBASEY COST AS OF ASSY OF ASSY	MITIAL SPARES SUBASEYS	TOTAL INITIAL SPARES SUBASEYS	MITIAL SUBASSY SPARES IN EES	TOTAL INITIAL SPARES IN EES	SPARES COMPO- MENTS	COMP COMP SPANES IN ESS	SPARES		SUBARY SYARES SYARES	TOTAL CHEN SPARES IN EES	. E Z > E	-68-31		E 5 23
				J	3	R-C-81	. C	iš	iğ.	CLUSIA	E	ğ	iQ#O	â	Ö	C12.50.	<b>2</b>	2	ĝ	200	- i
Main Engine Support	4.2			[0.53]		0				0	0					0.459	(0.459)				
Propellant Feed LHo Feedline Ball	4.2.1	-G	8.0	8.0	. •	S	0.033	0						7	o. . <del></del>	0.133		0.15	9	0.0 0	
Valve 102 Feedline Ball	4.2.1.2	3			٥			0			,			٦				0.15			
Valve 1/2 In. Check Valve Feedline Isolation	4.2.1.3	88			00			00						аа				88.			
tion Valves er Fitting iHg lief Valves tion Valves weg iOg	4444444 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,	-338330 -338330	8.	0.10	00000	<b>.</b>	0.00	00000						нанана	v	o.0 <del>4</del> 3		000000 0000000000000000000000000000000	.1.	0.013	
Fill, Drain, Abort Lig Valve Lig Valve Lig Disconnett Lig Disconnett	44444 666666 666666		8. 6	0.15	0000	0	0.017	0000					····		<b></b>	0.068		8828			
Pheumatic Control Valve Mods	4.2.4		8.	0.10	o ·	•	0.005	0							-	0.005		2.3		0.010	^
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Т		Т						 <del></del>						
~	TOTAL DEPOT SPARES IN EES	2		·				 						
8	TOTAL DEPOT REPAIR KITS IN EES	C1250,	8	3		0.010		 ·						:
2	TOTAL DEPOT REPAIR KITS IN EQUIV SUBASEYS	120.		6		989.								
9	DEPOT REPAIR KITS IN EQUIV SUBASEYS	á		90.0	0.02	0.00 0.32 0.03 0.03 0.03	0.003							
13	TOTAL OPER SPARES IN EES	<u>u</u>											,	d
16	OPER SUBASEY SPARES IN EES	C1 £50;		0.120		0.090					. <u></u>			
15	TOTAL OVER SPARES SUBASSYS	1380	•	<b>#</b>		9								\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
7	OPER SPARES SUBASSYS	8		ааа	٦	ааноа	нн	 				<u></u>		
13	OPER COMP SPARES IN ESS	P-Cj-SOj						 						•
2	OPER SPARES COMPO- NENTS	ã												
Ξ	TOTAL INITIAL SPARES IN EES	ū						 						÷
õ	BUTIAL SUBASSY SPARES IN EES	C12Si												
•	TOTAL INITIAL SPARES SUBASEYS	iSi							, <u></u>					(
	INITIAL SPARES SUBASSYS	Si		000	0	00000	00			<u>, , , , , , , , , , , , , , , , , , , </u>				· ·
_	AVG SUBASSY COST AS FRACTION OF ASSY COST	C.A.		0.030		0.015		 						1 ,
	INITIAL COMP SPARES IN ESS	R-C-Su											• • •	
s	INITIAL SPARES COMPO NENTS	ŝ		000	0	00000	000							
•	SPARE SPARES COST AS COST AS PRACTION COMPO COMPO COST OF ASS PRINTS	ū		0.15		0.30			····					
•	9 2 5 9 2	3 =		8.		8.		 						
~	NUMBER PER TUG			<b>-33</b> 3	(2)	400005								
-	<b>30</b> 00		4.2 (Cont'D)	10.00 20.00	4.2.5.4	44444 0,0,0,0,0 0,0,0,0,0 0,0,0,0,0	4.2.6.7					·		
	IDENTIFICATION		Main Engine Support (Cont'd)	acttor Probe scitor Probe scitor Probe acttor Probe	Capacitor PR Attach	S/O Valves	ice							

Options 1 and 31

Options 1 and I

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IGENTIFICATION	8	2 2 2	9#E 9#E	SCARE COST AS FRACTION OF ASST TOO	2 8 8 E	4.50	AVG SUBARY COST AS PRACTION OF ARY	₹8 €	448 F	INITIAL SUBABBY PARES IN EES	+ # B #	SPANES SPANES SPANES MENTS	- 2 12 10	OPEN SPARES LUBASEVE	TOTAL OPEN SPARES	OFFR SUBAREY SPARES IN EES	TOTAL COTEN PARES PRES	DEPOT MEPAIN KITS IN FOUNV LEASEVS	TOTAL DEPOT MEPAIN MITTS NE GOUNY	TOTAL DEPOT NEPAIN KITS N EES	TOTAL CEPOT WANES IN EES
			æ	σ	ž	#C-80	į.	ŝ	ā	CIES	E1	ğ	n-cyeo;	Ğ.	-081	C1280,	60	g	, OEL	C1230	2
ACPS Engine	E.4	_		[0.0]		٥					٥					_	(0.083)		98.0	600.0	(0.006)
ACPS Module MR-3C Engine R-30 Engine Thruster Isolation	<u> </u>	≠®®9 =======	0.225	1.0	0000		0.021							ппп	4	0.083		882			
Valve Thruster Control Valve	4.3.1.4	(35)			۰				<del></del>					٦	****			0.13			
ACPS Engine Support	#			[0.15]							0				-	<del></del>	(0.300)			<u> </u>	0.044)
Tank Tank Bladder	4.4.4 4.4.1.4	m®	8.0	8.5	۰	_ ⊗ (o,	 = 0.033)	•						۰,0		0.150	5	0.160 0.500	00	0.024	
Relief Valve - GHZ	444 444 967	44.		9.50	000	 `		000		· ········						0.030		0.000	-00	0.0002	
Fill Valve - Mall	. 4. 4. 4. 4. 4. 4. 6. 6.			393	000										<del>-</del>	0.030		0.050		0.0015	
Screen Filter Modified Isolation Valve	7.4. 7.4.	rl.#		9.0	00			00								0.000		0.021		9000.0	
					4.				_					,							
* Estimated at .20 of	.20 of tank cost	يد .																			
TESS . ECUNVALENT BUPSETS OF THE ABBINDLY ILEVEL &	HE ASSESSED	V ALEVEL 6																			ŀ

# PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL 2 & 3F

		Funct		Verifi	Verification Capability	ity					Stress	Use		Attrib.
Code No.	Functional Equipment Items	Prior To Flt	Parameter	Risk	Method	Locat	Test	No. Test	No.	10 <sup>6</sup> Hr			NAKT	Items R
1.	Structure			100								.251	12	
1.1	Fuel Tank				\$		<b>&gt;</b>	<del></del>			ư	0.25		
1.1.1	Access Cover Gaskets		Leakage	67	Hold Pressure	1.2.1	<b>≺</b>		N		`		}	
	Tank Repair Kit		Struct. Damage	33	Visual	1.1.7		×		-		<u> </u>	.015	
1.2	LOX Tenk										ı		·	
1.2.1	Access Cover Gaskets		Leakage	19	Hold Pressure	1.2.1	×		ο.		<u></u>		, c20.	
	Tank Repair Kit		Struct. Damage	33	Visual	1.1.7		×				<u> </u>	.015	
1.3	Body Struct.												9	
1.3.1	Paint		Appearance	9	Visual	1.1.7		×			<u>د</u>	j.	040	
1.3.2	Access Cover Panels		Tears/Cracks	04	Visual	1.1.7		×	. <del></del>		ľ.		.025	
1.4	Thrust Struct.												(	
1.4.1	Supports		Distortion	001	Visual	1.1.7		×			<b>د</b>	<u> </u>	.013	
1.5	Meteoroid Shield													
1.5.1	Shell Repair Kit		Pinctures	20	Visual	1.1.6		×			100	•	٠٥٥٠,	
1.5.2	Repair Kit - Fbglas.		Punctures	20	Visual	1.1.6		×			100	<u>ූ</u>	590.	
	-													
-														

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PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Veri	Verification Capability	lity				Fail/	G to to to			Attrib.
	Functional	Pri or		×						Hr		Time		Items
Code No.	Equipment Items	Flt	Parameter	Risk	Method	Locat	Test	Test	M	Y	×	E	MAKE	<b>×</b>
9.1	Payload Docking												.033878	
1.9.1		Part	No Binding		Actuate	2.2.3	×		<b>4</b>			нн	,00 4	
1.6.2	Latch Trigger (Adjust)	Part	Lock, Binding		Actuate	2.2.3	×		4			нн	400.	
1.6.3		Part	Release Latches	•	Actuate	2.2.3	×			3.0	200	ر د د	.007200	
1.6.4	8	Yes	Actuate Ret.		Actuate	2.2.3	×		Q,	1.0	5	15 178	.001930	
1.6.5	Docking Ring Assy	Yes	Struct. Sound		Visual	2.2.3	×		ri .		ط <sub>.</sub>	178	.000200	
1.6.6	Energy	Part	No Leakage		Visual	2.2.3	×		<b>&amp;</b>	3.0	~ 62	2	(.007200)	
1.6.1	Check Valves	0	Check Flow		Observ. Load	2.2.3	×		ဆ	.27	2	д_	(110000)	
1.6.8	3 Position Gang Yes	Yes	Open/Vent		Observ. Load	2.2.3	×		н	3.0	N.	10 178	(.002820)	
1.6.8.1	Solenoid Actuators	Yes	Position Valve		Geng Vlv Opn	2.2.3	×		α	(2.0)	5	п	(.000020)	
1.6.9	Vent/Relief Valve	Yes	Vent He		Calib.	1.1.7		×	<u>н</u>	1.0	<u>د</u>	178	(076000.)	
1.6.10	Tank	Yes	(In Preumatics)				·		н	1	1	1	<u> </u>	
1.6.11	Regulator	Yes	Cont. Press		Monitor Press.	2.4.2	×		а_	2.5	۷	178	(.002350)	
1.6.12	Hyd Accum	Yes	Store Hyd Fld.	·	Monitor Press.		×		н	1.34	<u>د</u>	178	(.001260)	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Verif	Verification Capability	lity				Fail/	ć			1,774
	Functional	Prior To		*				No.	No.		Factor	Use Tine		Attrio. Items
Code No.	Equipment Items		Parameter	Risk	Method	Locat	Test		Z		×	T	NAKT	œ
1.6.13	Spin up Drive Assy	No	Rotate S/c	ı	Test Drive	1.1.7		X	2	12.8	5	.5	( 1,900001 )	
1.6.24	Spin up Drive Idler	No	Position S/C	1	Test Opn.	1.1.7		×	н	9.	<b>ا</b>	v.	(,000064)	
1.6.15	Preumatic Actuator	N <sub>O</sub>	Engage Drive	,	Test Opn.	1.1.7		×	m	3.0	۲۷	'n	(.000023)	
1.6.16	Pneumatic Cont. No. Module		Open/Close		Test Opn.	1.1.7		×	н	2.0	۲۵	10	(.001880)	
										-			1100	
								-						

PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Verifi	Verification Capability	ty.						91		Attrib.
Code No.	Functional Equipment Items	Prior To Fit	Parameter	Risk	Method	Locat	Test	No. Test	No.	10 <sup>6</sup> Hr		Time	NAKT	Items
2.1	Insulation				Cold spots	1.1.4	<b>&gt;</b>						.030	Est.
7.1.2	(MLI)					1.1.6	×							
2.5	Insul. Purge		,								ı^		010211.	
2.2.1	Liner Repair		Leakage		Press Test	1.1.7	×				۷.		.0300	
2.2.2	Vent Valves		Open		Flow Rete	1.1.7	×_		m	1.0			.000150	
2.2.3	Regulator		He Press		Calib.	1.1.7	×		н	2.7	<b>ب</b>	10 177	.025245	***;
2.2.4	Press		Bag Press		Calib.	1.1.7	×_		H	5.9	ĸ	10 177	.055165	
2.2.5	Valves -		Open/Close		F ow Test	1.1.7	×_			1.0	٧	170	.000935	·
2.2.6	Solenoid Relief Valve		Hold Press		Monitor Press	2.4.2	<b>×</b>		н	٠.	٧	100	.000468	,
2.2.7	He Bottle		Hold Press		Monitor Fill	2.4.2	×		н_	.05	٥	10 177	.000047	
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# PREFLIGHT VERIFICATION OF SUBSYSTEMS

PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Verifi	Verification Capability	ity				Fail/		1		A++ w().
	Franct tone	Prior		*				No.	Q		Factor Tim	Time		Items
Code No.	Equipment Items Fit	Fit	Parameter	Risk	Method	Locat	Test				×	E	INAKT	<b>K</b>
3.1.5	Computer Interface Unit	Yes	Computer Opn	Est. 100	Computer Software	2.3.9	×		1	5	-	15 158	.006055	
3.1.6		Yes	Proper Voltage	Est. 100	Computer Software	2.3.9	×		9	2	2	15 158	.036330	
3.1.7	Unit	Yes	Commd. Data	Est. 100	Computer Software	2.3.9	×		1/3	04	-	15 158	044840.	
3.1.7.1	PC Board A					2.3.9	×		(9)	(8)	7		(.019376)	
3.1.7.2	PC Board B					2.3.9	×		(9)	(10)	7		(.024220)	
3.1.7.3	Box Misc					2.3.9	×	-	(3)	<del>3</del>	<b>-</b>		( 118100.)	
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### PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: 2 & 3F

		Funct		Verif	Verification Capability	ty				Fa11/				
	Functional	Frior		76				8	No.		Stress Use Factor Time	Use	<del></del>	Attrib. Items
Code No.	Equipment Items	Flt	Parameter	Risk	Method	Locat	Test				×	F	NAKT	49
3.2	GNC	ဗ္က	·	Est. 66.6									.547520	
3.2.1	DMI	_н_	·	4.17	·				1/2	120	ω	2 148	.504000	
3.2.1.1	Gyros	Yes	Stabilize	57.2	Meas. Speed	2.4.4	×		(9)	8	80	2 148	(.288000)	
3.2.1.2	Accelerometers	Yes	Displacement	28.6	Bench Test	1.1.13		×	(9)	140	80	2 148	(000441.)	
3.2.1.3	Sensor Electronics	Yes	Input-Output Data	5.7	Operating Data 2.4.4	4.4.5	×		(2)	<b>7</b> 2	∞	2 148	(.028800)	
3.2.1.4	Power Supply & Elect.	Yes	Power to Units	ts 4.8	Unit Funct.	2.4.4	×		(2)	8	∞	2 148	(.024000)	
3.2.1.5	Housing Assy & Coolent	Yes	Tempt. Cont.	3.8	Measure-IM	4.4.5	×		(2)	91	œ	2 148	(.019200)	
3.2.2	Star Tracker			91					1/2	30	8	148	.035520	
3.2.2.1	Sensor	<b>S</b>	Sense/Track Stars	0. 48	Light Table	1.1.13		×	(2)	(25)	œ	148	(0096201)	
3.2.2.2	Stabiliz, Drive No	0	Control Sensor Posit.	or 16.0	Test Response	1.2.1	×		(2)	(5)	œ	148	(.005920)	
3.2.3	Docking Radar												.008000	
3.2.3.1	Laser Radar	N N	Beam Dir.		Calibrate	1.1.7		×	н	500	80	ر. د	(008000)	
	41-42											·	<del></del>	
										, '			-	
	,													
-			**************************************		•		-							

0-44

PREFLIGHT VERIFICATION OF SUBSYSTEMS

Attrib.	Items R							•							
	IVKT	.237170	.018778	.005216	.063896	(9281300)	(.006520)	.012240	(.009792)	.013040	.013040	(35,4010.)	(.002608)	.33040	·
	Time		15	15 148	15	·	:	5 148	5 148	15	15	15 148	15	15 148	
. +	Factor Time K T	. ,`	∞	<b>&amp;</b>	<b>6</b> 0	©	<b>&amp;</b>	∞	œ	<b>&amp;</b>	∞	<b>6</b> 0	ω	•	
Feil/	10 <sup>6</sup> Hr		3.6	0.4	61	(11)	(5)	910	4	01	01	<u>.a</u>	α	10	
	N. N		<b>4</b>	н	п		(3)	н	a		н	α <u> </u>	н_	ਜ_	
	No. Test							×							
	Test		×	×	×	×	×			×	Part	Part	Part	×	
ty	Locat		2.4.1	2.4.1		2.4.1	2.4.1	1.1.13		2.4.1		2.4.1	,	2.4.1	
Verification Capability	Method		Test For IM	Test for IM	•	Monitor by TM		Interrog.		TM Command		Interrog. IM	Interrog. TM	TM Command	
Verifi	Risk	Set.	100	001	100			100		100	85			100	 
	Parameter		Data Output	Sequence Data		Voltage	Power Avail.	Relay Data		Equip. Function		Data Input	Data Input	Equip. Funct.	
Funct	Prior To Flt	m	H	н	×			×		H	'н.			<u> </u>	 -,
	Functional Equipment Items	Communications	Omni Antenna	R.F.	Power Amplifier x	Time	Circuitry	ler	PC Board	Command Decoder x	Processor (Mod/Demod)	PC Boards	Circuitry	PCM Encoder	
	Code No.	3.3	3.3.1	3.3.2	3.3.3	3.3.3.1	3.3.2		3.3.4.1	3.3.5	3.3.6	3.3.6.1	3.3.6.2	3.3.7	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

Oper T.R.	Read/Energize Tape Control Functions	Read/En Tape Control Functio	Read Tape Cont Func

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PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: 2

		Funct		Verifi	Verification Capability	ty				Fail/	300	981		Attrib.
Code No.	Functional Equipment Items	Prior To Fit	Parameter	% Risk	Method	Locat	Test	No. Test	Š ×	10,6 Hr		Tine	KAKT	Items R
3.3.10	Comsec Equip	No	Req Response	100	TM Date	2.3.9	×		7	01	80	5	.012240	
з.з.п	Transponder (STDN)	No	Relay Data	100	IM Data	2.4.1	×		-	01	σο	5 148	.012240	
3.3.11.1	PC Board								2	. <del></del>			(261600.)	
3.4	Instrumentation (Limited)	(Limit		Est.									.198495	
3.4.1	Sensors	×		9.5 2.5 2.5							80		.168495	
_	Strain	Yes	Continuity	\	Test software	1.2.1		×	97	.05	œ	1 148	(.000775)	
	Press. Transducers	Yes	Press Actuation		Loading Opns	2.4.2	×		25	۲.	8	2 148	(000800)	
	Temp.	Yes	Temp Actuation		Loading Opns	2.4.2	×		8	m	80	15	(.117360)	
	Position	Yes	Position Indic.		Checkout	1.2.1	Part.		8	8	∞ ,	148	(.047360)	
3.4.2	Signal Conditioning	×		<b>Est.</b> 85					т.	25	80	2 148	(.030000)	
	Misc.	Yes	Signal Char.		Test Software				65	<b>ب</b>	ω			
3.5	Elect. Power		· ·	7.66									117650.	
3.5.1	Fuel Cell PP	Yes	Power Output	4.66	Monitor Volts	4.4.5	×		1/2				.026597	
3.5.1.1	Power Cell Stack	Yes	Reactant Flow	74.2	Monitor Volts	7.4.2	×		1/5	8.5	<b>ا</b> ر		(.019743)	
3.5.1.2	Reactant Cont. Valves	Yes	Open/Close	5.6	Press. Sens.	4.4.2	×		<u> </u>	1.0	2	176	(.001,490)	
							·							
	<del></del>													

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL 2

		Funct		Verifi	Verification Capability	ıty				Fail/	3	, ,		Attrib
	Functional	Prior To		**				No.	₹o.	끍	Stress use Factor Tim	Time		Items
Code No.	Equipment Items	Fit	Parameter	Risk	Method	Locat	Test				×	E	NAKT	œ
3.5.1.3	Coupled Regulators	Yes	Pressure	14.0	Monitor Inst.	2.4.4	×		#	2.5	2	) 641	(.003725)	
3.5.1.4	Reactant Scrubbers	Yes	Remove Contam.	9.0	Press. Sens.	4.4.5		×	4	0.1	٧.	) 6†1	(671000')	
3.5.1.5	Vent Valves	Yes	Press. Relief	5.6	Monitor Cycle	2.4.4	×		<b>4</b>	1.0	2	176	(064100.)	
3.5.2	Fuel Cell Reactant Syst.			100								<u></u>	411120	
3.5.2.1	02 Tenk	Yes	Leaks		Monitor Press.	2.4.2	×		-	.05	2	177 (	(.000047)	
3.5.2.2	N <sub>2</sub> Tank	Yes	Leaks		Monitor Press.	2.4.2	×		н	.05	72	10 (171	(7,00000.)	
3.5.2.3	0 <sub>2</sub> Fill Valve	Yes	Open/Close		Fill Cycle	2.4.2	× .		п	1.0	٧.	100	(30000.)	
3.5.2.4	02 Vent/ Relief Valve	Yes	Setting		Monitor Press	2.4.2	×		н	4.34	2	10	(.004058)	
3.5.2.5	H2 Fill Valve	Yes	Open/Close		Fill Cycle	2.4.2	×		н	1.0	ľ	10	(366000.)	
3.5.2.6	H <sub>2</sub> Vent/Relief	X X	Setting		Monitor Press.	2.4.2	×		н_	₩.4	٧		(.004058)	
3.5.2.7	O <sub>2</sub> Tank Press. Cage	Yes	Function		Monitor Press.	2.4.2	×		н	5.9	2	10 177	(712500.)	
3.5.2.8	H2 Tank Press. Cage	Yes	Function		Monitor Press. 2.4.2	2.4.2	×		н	5.9	۲.	177	(.00517)	
						·								
						· · · · · · · · · · · · · · · · · · ·								
	:													

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: 2

,													·	
A++ +- ( )	Items R							· .	<u>-</u>		•		d	
	HAKT	.012000		.007824	(.006520)	(40£100.)						 		
<u> </u>	TI Be	2 148			15 148	15 148								
	Stress use Factor Hime	80			<b>6</b> 0	€								
Fail/	10 <sup>6</sup> Hr	07			•••	<b>ਜ਼</b>				 		 		
	No.	-		н.	10	01						 		
	No. Test									 				
	Test	×											,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
ty	Locat	2.4.4		2.4.4	4.4.	ग॰ग॰ट						 		·
Verification Capability	Method	Final C/O			Use in C/O	Use in C/O								
Verifi	Risk	100		700										
·	Parameter	Power Avail	Replace after each flt.		Power Avail	Power Avai.l								
Funct	Prior To Fit	Ī			Yes	Yes						 		
	Functional Equipment Items	Primary Battery Yes		Power Distribution	,	30 30 30 30								
	Code No.	3.5.3		3.6	3.6.1	3.6.2	1							

### PREFLIGHT VERIFICATION OF SUBSYSTEMS

		<b>Funct</b>		Verifi	Verification Capability	ty				Fe11/				++
Code No.	Functional Equipment Items	Prior To Flt	Parameter	Risk	Method	Locat	Test	No. Test	No.	10 <sup>6</sup> Hr	Factor Time  K T	Tine T	HAKT	Items R
4.0	Propulsion													
4.1	Main Engine			0	,			•						
4.1.1	Main Engine			0						14000	တ	.50	.056000	(.034237)
4.1.1.1	Igniter		Energy Avail		Excite	1.1.7		×		20.0		.50		Combos
4.1.1.2	Ignition Exciter		Energy Avail		Apply Power	1.1.7		×	н	5.0	<b>~</b>	. 50	(.000020)	
4.1.1.3	Prestart Solenoid Vlv		Open/Close		ActPosit. Sens.	1.1.7		×	ч	0.11	∞	57	(,005016)	
4.1.1.4	Prestart He Press. Sw.		Open/Close		ActPòsit. Sens.	ı		×	н	1.5	ω	57	( 10000684)	
4.1.1.5	Start Solenoid Vlv		Open/Close		ActPosit. Sens.	1.1.7		×	н	11.0	80	57	(910500.)	
4.1.1.6	Start He Press. Sw.		Open/Close		ActPosit. Sens.	1		×	<del></del>	1.5	∞	57	(.000684)	
4.1.1.7	Igniter Oxid. Supply Vlv		Open/Close		ActPosit. Sens.	1.1.7		×		9.	∞	21	(.000274)	
4.1.1.12	Main Fuel S/0		Open/Close		ActPosit. Sens.	1.1.7	,	×	-	11.0	œ	8	( 1,40000.)	
	Oxid. Flow Cont. Vlv		Not Feasible							•			<u>. 1 1</u>	
	Inrust Cont. Valve Oxidizer Pump	<u> </u>	to kepiace Without Engine Overhaul							1° <b>1</b>		·	<u>.</u>	
4.1.1.8	Fuel Pump Fuel Pump Disch. Cool		Open/Close		Act. Posit.	1.1.7		×	н	۲۰,	<u>د</u>	ŀ.	_ (.000013)	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Verif	Verification Capability	ty				Fa11/	24 7000			Attrib.
Code No.	Functional Equipment Items	Prior To Fit	Parameter	% Risk	Method	Locat	Test	No.	o ×	10 <sup>6</sup> Hr		Time	NAKT	Items
4.1.1.9	Fuel Pump Interstage Cool Bown Vlw		Open/Close		Act. Posit.	1.1.7		×	н	5.	2	3.	(.000015)	
4.1.1.10	Oxid. Inlet S/O		Open/Close	- <del></del>	Act. Posit. Sens.	1.1.7		×		9.	٧	ŗ.	(300001)	•
4.1.1.11	Fuel Inlet 8/0 Valve		Open/Close		Act. Posit. Sens.	1.1.7		×	н	9.	5	ċ.	(.000015)	
4.1.1.15	Sensors/ Transducers					•1		×	<b>&amp;</b>				(2,1110.)	
4.1.1.15.1 Press	Press		Read Press		Fit. only			×	#	0.9	<b>6</b> 0	57	(408600.)	
4.1.1.15.2 Temp	Temp		Read Temp		Flt. only	1	****	×	m	1.0	œ	57	(898100.)	
4.1.1.15.3 Speed	Speed Transducer		Read RPM		Eng. Oper Only	1		×	H	5	<b>1</b>	'n	(.000012)	
4.1.1.13	Gimbal Assy		Crack		Visual	1.1.7		×	-		സ	٠.	(.000002)	
4.1.1.14	Interstage Bleed & P/R Vlv		Open/Close		Act. Posit. Sens.	1.1.7		×	Н	11	<b>ب</b>	'n	(.000028)	
4.1.1.16	Fuel Tank Press		Open/Close		Act. Posit. Sens.	1.1.7		×	а	ю	<b>~</b>	ċ	(,000007)	
4.1.2	Gimbal Actuators (TVC)			0	,				N		ω	1.0	(,000924)	
4.1.2.1	Motor Actuators		Actuate Schew		Operate/Visual	1.1.1		×	<b>∄</b>	10.89	∞	.5.0	(.000522)	
4.1.2.2	Magnetic Clutch		Actuate Screw		Operate/Visual	1.1.7		×	( <del>†</del>	2°#	<b>6</b> 0	1.0	(411000.)	
4.1.2.3	Velocity Xducer		Measure Vel.		TM Feedback	1.1.7		×	€	ĸ.	<b>&amp;</b>	1.0	(.000012)	
	•				•									

# PREFLIGHT VERIFICATION OF SUBSYSTEMS MODEL 2 & 3F

Functional	Funct Prior To		Verif	Verification Capability	t d		No.	No.	Fail/	Stress	Use		Attrib.
Fit		Parameter	Risk	Method	Locat	Test	rest	N N	70 HF	ractor K	T	NAKT	l tems R
		Measure Posit.		TM Feedback	1.1.7		×	(†)	.13	ဆ	1.0	(900000.)	-
	-	Feedback Sign.		Operate	1.1.7		×	(7)	5.6	œ	1.0	(.000270)	
<u>E</u> +	E	Travel		Operate-Travel	1.1.7		×	(2)	.001	ω	1.0		
ຶ້	စ္မ	Seal Unit.		Visual	1.1.7		×	(2)	.001	œ	1.0	1	
e E	E	Relief Setting		Test Pressure	1.1.7		×	(2)	.001	ω	1.0		
<del></del> -			69.3	Verifiable					9.6	2		989110.	
No	e S	Seal Fuel	23.1	Tank Leak Test	1.1.7	×		н	3.0	2	2	.002685	
No	ĕ	Seal Oxidizer	23.1	Tank Leak Test	1.1.7	×	·		3.0	٧.		.002685	
Yes Ch	Ř	Check Flow	15.4	Isol. C/V Test 1.1.7	1.1.7		×	н	2.0	٧.		.001.790	
Yes Sens Pos.	ě Š	e Valve	11.5	Valve Posit.	1.1.7	×		. н	1.5	5		.001343	
No Op	<u> </u>	Open/Close	ı	Act. Valve	1.1.7		×		4.0	2	0.5	.000001	
<del></del>			•										
Yes Se Po	× 0	Sense Valve Pos.	п.5	Valve Posit.	1.1.7	×	- <del></del>		1.5	<u>د</u>	2 .	.001343	
	ł						-						

PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Verif	Verification Capability	ty				Fad1/				
Code No.	Functional Equipment Items	rnor To Flt	Parameter	% Risk	Method	Locat	Test	No. Test	ě z	10 <sup>6</sup> Hr	Factor Tim	Tine Tine	INCE	Attrio. Items R
4.2.1.8	1/2-In. Check Valve	Yes	Check Flow	15.4	Isol. C/V Test 1.1.7	1.1.7		×	н	2.0	5	2 177	.001790	
4.2.1.9	Ball Valve Pneu. Actuat.	<u>%</u>	Open/Close		Act. valve	1.1.7		×	<i>,</i> -1	4.0	۲,		.000001	
4.2.2	Vent (#1)			9.95					н		<b>ا</b>		.048258	
4.2.2.1	Isolation Valves - LH <sub>2</sub>	No	Leak to Vent	16.9	Test for Leaks 1.1.7	1.1.7		×	4/2	3.4	2	2 177	.012172	
4.2.2.2	Tug/Orbiter Ftg Yes		Leak at Face	8.	Halogen Test	2.3.9	×		~I	1.96	2	2 177	.001754	
4.2.2.3	Vent & Relief Valves - LH <sub>2</sub>	Yes	Open to Vent	28.3	Relief Setg.	1.1.1	×		~	5.7	٧.	2 177	.010203	
4.2.2.4	Isolation Valves LO2	SK N	Leak to Vent	16.9	Test for Leaks	1.1.7		×	2/4	3.4	2	2 177	.012172	
4.2.2.5	Tug/orbiter Ftg 10,	Yes	Leak to Face	8.4	Halogen Test	2.3.9	×		н	1.96	2	2 177	.001754	
4.2.2.6	Vent & Relief Valve LO <sub>2</sub>	Yes	Open to Vent	28.3	Relief Setg.	1.1.7	×		cu_	5.7	2	2	.010203	
4.2.3	Fill & Drain			700					н				.018351	
4.2.3.1	F&D Valve-LH2	Yes	Open/Close Leak	34.5	Fill Cycle	2.4.3	×		en	3.4	<u>د</u>	2 177	.009129	
4.2.3.2	F&D Valve-LO2	Yes	Open/Close Leak	æ.5	Fill Cycle	2.4.3	×		m	3.4	2	2177	.009129	
4.2.3.3	Disconnect LH2	Yes	Seal to Orb.	10.3	Halogen Test	2.3.9	×		-1	1.96	æ	Q	.000031	
4.2.3.4	Disconnect LO2	Yes	Seal to Orb.	20.7	Halogen Test	2.3.9	×		Q	1.96	80	a	.000062	
4.2.4	Preumatic			6									041140.	
1.4.5.4	S/O Valve Modules	Part	Open/Close	700	Actuate Valves 1.1.7	1.1.7	×	···	22	2.0	5	10 177	(.041140.)	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

		Funct		Verif	Verification Capability	ity				Fail/	2000.40			Attrib
Code No.	Functional Equipment Items	Prior To Fit	Parameter	Risk	Method	Locat Test Test	Test	No. No. Test N	No.	10 Hr Factor Time	Factor	Time	NAKT	Items R
4.2.5	Propellant Utilization			24.9					н		-		.012357	
4.2.5.1	IH2 Capac.	Yes	Quantity Meas. 12.1 Monitor Fill	12.1	Monitor Fill	2.4.3 X	×		п	1.0	∞	10 177	964100.	
4.2.5.2	LO2 Capac. Probe	Yes	Quantity Meas. 12.1 Monitor Fill	12.1	Monitor Fill	2.4.3 X	×		н	1.0	œ	10	.001496	
4.2.5.3	Prop. Utiliz Assy	No.	Control Flow	75.1	75.1 Calib.	1.1.7		×	н	6.2	80	10 177	.009275	
4.2.5.4	Capac. Probe Attach.	Yes	Seal Tank	-0.7	-0.7 Hold Press.	1.1.7 X	×		0	.05	2	2177	060000.	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: 3F

Attrib	Items R																
	NAKT	.066700	(1,60000.)	(.0000050)	(.001770)	(.001770)	1	(.001870)	(326000.)	(3000035)	(62,0000.)	(6800000.)	(.002212)		(.002212)	(.000885)	
12	Tine		10 177	-	177	177	•	10 177	10 177	177	177	177	177	177	177	111	
*			<b>ا</b> ر	2	'n	<b>ا</b>	~	<b>'</b>	2	5	2	<b>د</b>	~	ı,	5	<b>د</b>	
Fail/	10 <sup>6</sup> Hr	52.1	.05	6.6	1.0	1.0	1.0	2.0	1.0	1.0	.27	.05	2.5		1	1.0	
	Š z		a	_ <del></del>	N N	N N	CV.	н		<del></del>	ر د	c <sub>V</sub>		α	н_	-	
	No.			×	×	×	×				×		×	×	×	×	
	Test		×					×	×	×		×					
<u>ج</u>	Locat					1			<del></del>							1	
Verification Capability	Method	Testable	Press in He	Temp Sensor	Press at Burner	Press at Burn	Flow at Burn	Press in Ne	Press. in Tank	Press. in Tank		Hold Press	Flowrate		Flow Rate	Valve Posit.	
/erifi	% Risk	85.07	4r.	.07	2.65	2.65		2.80			.72	.13	3.32	ı	1	1.33	
	Parameter		Press. Volume	Burn Temp	Valve Open	Valve Open	Supply Flow	Hold Press	Valve Position 1.40	Valve Position 1.40	Check	Leak	Press-Flow	Flow to Tank	Flow Rate	Valve Posit.	
Funct	Prior To Fit		Yes	No	S.	No	2	Yes	Yes	Yes	Yes	Yes	No	Yes	S S	2	
	Functional Equipment Items	Pressurization Heated He + Eng. GH2 Bleed		0 <sub>2</sub> -II <sub>2</sub> Burner		IH2 Supply	Supply Orifices No	Disconnect	He Solenoid	He Solenoid Valves - LH2	He Check Valves Yes	Plenums	ator	LO2-LN2 Press Yes Orifices	GN2 Orifice	9	
	Code No.	4.2.6	4.2.6.1	4.2.6.2	4.2.6.3	4.2.6.4	4.2.6.5	4.2.6.6	4.2.6.7	4.2.6.8	4.2.6.9	4.2.6.10	4.2.6.11	4.2.6.12	4.2.6.13	4.2.6.14	

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL 3F

Attrib.	Items										:		·.		,				
	NXKT	(,000239)	( % Z Z Z Z Z Z Z Z Z Z Z Z Z Z Z Z Z Z	(98856)		(964100.)	(000000)	(.016897)	(.016897)		(.002543)	(.008527)							
Use	Time T	177	11.	9	177	10 177	٦_	2	2 177	2 177	10	<u>.</u> ភ	177						
Stress		5	<b>ω</b>	œ	•	&	<b>∞</b>	<b>ω</b> ΄	80	1	CV .	8	· · · · ·			_			
7.	10 <sup>6</sup> Hr	.27	.27	C	×.	1.0	1.0	5.9	5.9	1	3.4	5.7							
	N N	-			-	<b>н</b>	<u> </u>	2	ય	0	α	-	1				·		_
	No. Test		×				×			×	×							·	
	Test	×		;	×	×		×	×			>	<u> </u>			<del></del>			_
'n	cat			-											٠.		٠		
Verification Capability	Method	Held He Press.	Leak Test	-	Press in He 90	Temp in LH2 90	Temp in Burner	25.40 TM Sensor	25.40 TM Sensor		Posit. Sensors	. (	12.80 Tank Press	٠.				·	
erific	Risk	.36 H			13.3 I	2.2 <sup>th</sup> 1	٠ <u>.</u>	25.40	25.40	,	8		12.80						
Λ	Farameter	1			Tank Press.	Tank Temp.	Burner Temp	Prefit Press	Prefit Press.	Flow Rate	Valve Position		No Leak						
Funct	Prior fo				Yes	Yes	No	Yes	Yes	Yes	Ç <u>N</u>		Yes					,	
-		-		Gh2 Check val. Redund	<b>6</b>	Sensor He Temp Sensor	Burner Temp	Sensor LH, Tank Press. Yes	Señsor LO <sub>2</sub> Tank Press	Sensor LO. LHo Tenk	Diffusers	Press. Valve	Vent & Relief Valve	-			1 <del>-</del>		
	;	Code No.	4.2.0.17		4.2.6.16	1,2.6.17	4.2.6.18	4.2.6.19	h.2.6.20	10.90		4.2.0.24	4.2.6.23						

PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: TUG OPTION 3F

		Funct		Verif	Verification Capability	1ty				Fe11/		:		
-	Functional	Prior		×				No.		10 <sup>6</sup> Br	Factor Time	Time		Items
Code No.	Equipment Items	Flt	Parameter	Risk	Method	Locet	Test	Test	×	~	×	E∙I	NAKE	nci
.3	ACPS Engine												145797	
4.3.1	ACPS Module			0	:			,	 .⇒			8	.016589	
4.3.1.1	R-4D Axial Thruster	<b>%</b>	Flow Rate	3.7	Calib.	1.1.12		×	<b>&amp;</b>	. 16	10	84	.000614	
.3.1.2	R-lE Tang'l Thruster	<u>Q</u>	Flow Rate	3.7	Calib.	1.1.12		×	ω	.16	01	89	(,000614)	
4.3.1.3	Thrustor Iso Vlv	<u>Q</u>	Open/Close	1,6.3	Monitor	1.1.12		×	32	1.0	Ŋ	8	(.007680)	
4.3.1.4	Thrustor Chamb. No	N N	Open/Close	46.3	Moni tor	1.1.12		×	8	1.0	5	<b>8</b>	(.007680)	
	ACPS Support			91.2					-				.129208	
۲.	Tank (MAH)	. <b>X</b>	Leak	13.9	Monitor Press	2.1.7	×		α <u> </u>	9.6	در	10 177	.017952	
4.4.2	Tenk (N <sub>2</sub> O <sub>4</sub> )	Yes	Leak	13.9	Monitor Fress	2.1.7	×		N	9.6	٧.	10 177	.017952	
4.4.2,1	Tark Bladders	Xes X	Leak		Monitor Press	2.1.7	×		(2)	9.6		10	(.017952)	
h.4.3	Relief Vlv	X SS	Press Setg	11.1	Monitor Press	2.4.2	×		e E	0.5		10 177	.001403	
4.4.3.1	Burst Disk	Tes	Press Setg		Monitor Press	2.4.2	H		(3)	1.0		100	(.0002&L)	
ग ग ग	Grnd Quick Discon	Yes	Leak	ω. Θ	Monitor Fill	2.4.2	×		N .	1.96		100	.003665	
4.4.5	Fill/Drain & Disconn	Yes	Leak	1.5	Monitor Fill	2.4.2	×		8	0.		10	.001870	
9.4.4	Module Iso Vlys Yes		Leak	5.8	Monitor Press	2.4.2	H		<u> </u>	1.0		177	.007480	
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PREFLIGHT VERIFICATION OF SUBSYSTEMS

MODEL: TUG OPTION 3F

4 + 4	Action Items	œ											•				<del>-</del>	
		NAKT	.001870	.000935	.001833	(706910.)	.003740	.006637	.005841	.000027	140000°	.000018	.037026	.019831	.003840			
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	No.	z	a	н	-	н	€	(3)	(9)	(3)	(1)	(3)		_	#	 		
	No.	Test			×	×		×	×	×	×	×	- <del></del>			 		
		Test	×	×			×						×	×	×			
ty		Locat	2,4.2	2.4.2	1.1.7	1.1.7	1.1.7	1.1.1	1.1.7	1.1.7	1.1.7	1.1.7	2.4.2	2.1.7	2.1.7			
Verification Capability		Method	Monitor Press	Tank Press.	Syst. Test	Press at Tanks 1.1.7	Press at Tanks 1.1.7	Press at Tanks 1.1.7	Press at Tanks 1.1.7	Press at Tanks 1.1	Press at Tanks 1.1.7	Press at Tanks 1.1.7	Monitor	Monitor	Software			
Verifi	74	Risk	1.5	۲.	4.1	12.6	2.9		-				28.7	15.4	3.0			
		Parameter	Leak	Open/Close	Check Flow	Open/Close	Leak	Cont. Press	Power	Flow	Power Avail.	Power Avail.	Sense Press.	Sense Temp.	Proper Mod Cmds			
Funct	Prior	FIt	Yes	Yes	No No	Yes	Yes	No	Q	No	No	No	Part.	Part	Yes			
	Functional	Equipment Items	Grad Red He	Fill/Drain S/O	Fill/Prain Check Viv & CD	He Press	S/0 VIvs	Press. Regs.	Switch (Press.) No	Filter	ML Relay	DRDT Switch	Press. Sensors	Temp. Seusora	Module Inst. Connect			
		Code No.	2.4	8·h.	6.4.	υ <b>τ.</b> 4.10	1.01.4.1	1.4.10.2	1.4.10.3	4.01.4.	1.4.10.5	9.01.4.1	1.4.11	h.12	1. h.13			

Rev 9-3-73 Date 8-10-73 ton of M (0.005) (0.005) Kits-Debot (0.005) (0.03) (0.01) (0.05) 8 8 8 8 Repair 0.3 Assegns Por Spares (Est 2 2 1 ---STACK 840 N N **Kese**qng ä Component × ×  $\times \times$ × Repair 7 Subassy ××× × Replace S BIFE 0.065 0.065 0.130 0.065 0.325 Subassy | TOO LTER 1.3 2.6 Subessy Failed\ (S40) X2013 Component Float Component Initial Stock 0000000000 TUG SPARES ANALYSIS - M ENGINEERING Bul Tisqean 1 Maintenauce × UMI/qmoD ××××× ××× **≍**ູ × врдесе eata s 0.036 0.02 0.02 0.035 0.009 0.180 Ingent Fei lures M/A Cont 0.72 0.001 0.0126 TOO LIFE 4.4.000 0.000 0.000 Per 2.6 3.9 2.6 Failures Per Tug 3773 4<u>6</u>6469 て 60 80 で す ち ち ち ち ち ち Access Baskets
Structure Repair Kit
Body Structure
Paint
Cover Panels and Orbiter Kit Interface
Thrust Structure
Repair Kit
Repair Kit - AL on 3F GR Epoxy
Repair Kit - AL on 3F GR Epoxy
Repair Kit - Fiberglass
Payload Docking Functional Equipment (Assembly, Component, Subassembly) Subassembly Level ? Component Level ? Assembly Level 6 Structure Drive Mechanism
Frame Tube Structure
Energy Absorbers
Check Valves
Hyd Accum Docking Ring Assembly Frame Retract Motor Access Gaskets Structure Repair Kit Oxidizer Tank Latch Trigger Retract Cylinder He Valves

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Repair Subassy at Depot

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9000	Repetr Tug		· · · · · · · · · · · · · · · · · · ·		
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	mably Level 8 ant Level 7 ly Level 6 lyment , Submassmbly)				
	Code - 1.1.1.1.— Subassembly Component Le Assembly Component, Suba Avionics	Data Management Computer Central Frocesor Memory Stack Elect. Misc. (Box Repair)	Module Interface Unit BIV PCU DCU RMU DIV SCU BCU DIV	Computer Interface Unit Instrument Power Supplies	
	Code	3.1.1 3.1.1.1 3.1.1.2 3.1.1.2	33.1.2.2.3 3.1.2.2.2.3 3.1.2.2.2.3 3.1.2.2.3 3.1.2.2.3 3.1.2.2.3	3.1.5	

Date 8-27-73

Color   11111   Color   11111   Color   11111   Color   11111   Color   Colo				· · · · · · · · · · · · · · · · · · ·			
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Code - 1.1.1. — Subsessently Lave 1 6    Component Lave 1 7			449	<b>श्रु</b> त्ते लेल न	0 O		
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Code - 1.1.1.1 — Subassembly Level 7	Texe?		o .	ณ <b>่</b>	<i>•</i>		
Code - 1.1.1. — Subassembly Level 7  Assembly Level 7  Assembly Level 6  Functional Equipment (Assembly, Component, Subassembly)  Pr Board A  Pr Board A  Pr Board A  Pr Board A  Pr Board B  Box Misc  Ouidance Navigation and Control  1100  Gross  Accelerometers  Sensor Electronics Power Supply and Electronics Power Supply and Electronics Bonsor Electronics Fower Supply and Coolant  Star Tracker  Sensor  Star Inacker  Stabilization Drive  TV Camers and Lights  I Laser Radar	_		-3	0	<b>1</b> C	0	
Code - 1.1.1.1 — Subassambly Lavel 6    Camponent Lavel 7   Camponent Lavel 6			<b>8</b>	50.4	ε. Σ.	8.0	
Code - 1.1.1.1 — Subassambly Lavel 6    Camponent Lavel 7		Snr sas		· · · · · · · · · · · · · · · · · · ·		·····	
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TUC SPAREE ANALYSIS - M ENGINEERING Option 2-5 By Downs Date 8-29

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	3	Kits-Debo Repair Subessy	1.20	04.5	3.82	0.15	0.0	0.69	8.0	3.90					
ace		Spares Ops Subsessy	н	-	QI PI	-AA-	7	нан		нн				-	
Maintenance		Repeir Component			24	<del></del>									
=		anpessa Rebrece			××			××		××	•				
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nance		Compliki									 	-	<u></u>		 $\dashv$
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1.3		Fellures Fer Fer	1.88	0.52	6.39	1.22	1.30	1.30	1.30	7.34			ţ		
		Number Per Tug	4	-1	<b>⊣</b> €3	(2)	-	- @ <del>_</del>	н	01 01 01 01					
1	Subassembly Level 5 Component Level 7 Assembly Level 6	Functional Equipment (Assembly, Component, Subassembly) Avionics				•		(pom							
	Code - 1.1.1.1	Funct: (Assembly,	Communications OMNI Antenna	RF Multiplexer	Power Amplifier TWT Circuitry	Transponder-Signals PC Board	Command Decoder	Processor (Mod/Demod) PC Board Circuitry	PCM Encoder	Tape Recorder Tape Drive Mechanics Magnetic Heeds Electronics					
		Code	3.3 3.3.1	3.3.2	3.3.3 3.3.3.1 3.3.3.2	3.3.4.1	3.3.5	3.3.6 3.3.6.1 3.3.6.2	3.3.7		 				

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TUG SPARES ANALYSIS - 4 EMMINERING

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Option

at Depot \*\*\*\* \*\*\*\*\* ă 55 Repair Subassy 1.3 0.10 0.25 0.00 0.10 1:5 0.25 Kita-Depot 2.8 Repair Subassy Speres 240 4  $\alpha$   $\alpha$   $\alpha$   $\alpha$ **ааааааа** Maintenance Subasay Component Repair Subassy XXXXX 1 уерласе Level S Fits 0.10 0.007 0.019 0.001 Submesy Pailed/ TOO LIFE 1.97 0.15 0.37 0.01 0.15 Submary Failed (SdO) \*2015 ٦ a Component Float Initial Stock Ö 00 0000000 н Component Maintenance Repair Tug × Replace Comp,LHU \*\*\*\*\* × × 933 0.005 0.005 0.003 0.03 2 Effe 90.0 0.13 Per 00 Fai Lures TOO LIFE 0.005 0.005 0.094 0.41 0.41 0.55 2.8 0.78 2.66 Per Failures Per Tug \_\_\_\_\_ ELEEDO 22 Number - Subassembly Level Component Level 1 Functional Equipment (Assembly, Component, Subassembly) Power Distribution

Power Distribution Components
Wire Harnesses (Kit) Cell Reactants System Avionica Resotant Control Valves Coupled Regulators Reactant Scrubbers Vent Valves Tank Pressure Gage Tank Pressure Gage Primary Battery Fuel Cell Fuel Cell PP Elect Power Tenk Tenk Code 3.5 3.5.1 3.5.1.1 3.5.1.2 3.5.1.2 3.5.1.4 3.5.3 3.6 3.6.1 3.6.2 Code

	Repair Subassy as Depot	***	
	Subessy Kits-Depot Kits-Depot	0.3 0.015 0.04 0.08 0.2 0.2 0.15 0.15	
901	Speres OPS Speres	ннооононо ннян	
Maintenance	Repair Component		
II Mai	Зпрваву Керласе	× ×	
Level I	Subessy Failed/ 5 Flts	0.003	
	TOO LICE Leiled/ Zubessy	0.053 0.011 0.001 0.001 0.027	
	Component Float Stock (SPS)		
	Component Statistal Ctock	0 0000	
eoue:	Repair Tug		
Maintenance	Replace Comp/LMU	ж жжж	
Level I	S Pite	0.005	
	Failures Per 100 Flts	0.09	
	Number Per Tug	0005£££££	
	iy Level 5 Level 7 Level 6 ment sent Subassy)		
	de - liii Subassenbiy Level Component Level Assembly Level 5 Functional Equipment (Assembly, Component, Subassy) Main Engine (Cont'd)	Gimbal Actuators Motor Actuators Magnetic Clutch Velocity Transducer Servo Amplifier Ball Screw Bellows Case Valve Main Engine Support Propellant Feed Fropellant Feed LIZ Feedline Ball Valve LO2 Feedline Ball Valve 1/2-in. Check Valve	Feedline Isolation Monitor
	Code - 1.	Gimbal Actu Motor Actus Megnetic CJ Velocity TY Position Th Serro Ampli Ball Screw Bellows Case Valve Main Engin Propellant IR2 Feedili 1/2-in. Ch	Feedlin
	Code.	1	4.2.1.4

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	Repair Subassy at Depot	×. ×	***	×	***	
	Kits-Debot Rebeit Subesey	0.816 0.120 0.120 0.682 0.816 0.120	0.00 0.00 0.00 0.00 0.00	2.75	0.100 0.100 0.620 0.020	
<b>9</b> 02	Suberes Speres	ннанна	ਜ <b>ਜਜ</b> •	O)		
Maintenance	Repear Component					
II Ma	gnpessà Reblece					
Level	Submesy Failed 5 Fits					
	700 Effs Entled			•		
	Component Float Stock (OPS)					
	Component Nooto Lettini	00 000	0000	•	0000	
Meintenanne	Repair Tug			·		
	Replace Comp/LRU	****			****	
Level :	Fellures Per 5 Fits	14.000000000000000000000000000000000000	0.0000	0.206	0.062 0.008 0.008 0.016 0.0005	
	700 Efts ber Estjures	- 1	0.91	1.1. (1.1.)	1.237 0.150 0.150 0.928 0.009	
	Number Per Tug	-33 <b>0</b> 333	-6666	, d &	-3338	
	A hevel c hevel c ent cubessy)				žt.	
	Code Component Le Component Lev Functional Equipment (Assembly, Component, Sul Main Engine Support	Vent Isolation Valves LH2 Tug Orbiter Fitting Vent and Relief Valves Isolation Valves LO2 Tug/Orbiter FTG LO2 Tug/Orbiter FTG LO2	Fill and Drain (and Abort) Valve LD2 Valve LD2 Disconnect LH2 Disconnect LO2	Pneumatic Control Valve Modules	Propellant Utilization LH2 Capacity Probe LO2 Capacity Probe Propellant Utilization Assembly Capacity Probe Attach Gasket	
	Code.	T C C C C C C C C C C C C C C C C C C C		1.2.4 4.2.4	44444 7.5.5.9.9 6.5.5.9.9 6.5.9	

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Γ	Repair Subasey at Depot	××××±×××±±×±±±±±±±××
	Submasy Repair Kits-Depot	0.000 0.003 0.125 0.006 0.006 0.006 0.007
:ce	Spares Ops Spares	
Maintenance	Repair Component	
=	Replace Subasay	
Level	Subassy Failed/ 5 Flts	
	Subassy Failed/ 100 Fits	
	Component Float Stock (OPS)	
	Component Initial Stock	000000000000000000000000000000000000000
nance	Repair Tug	
Maintenance	Replace URA\qmoO	********
evel:	Pailures Per 5 Fits	0.008 0.009 0.005 0.002 0.004 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.006 0.005
	Failures Per 100 Fits	0.009 0.178 0.178 0.178 0.187 0.094 0.094 0.094 0.094 0.098 0.098 0.088 0.18 0.15 0.088 0.15 0.088 0.15 0.088
	Number Per Tug	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Code - 1.1.1.1 Subassembly Level 8	Assembly Level to Functional Equipment (Assembly, Component, Subassembly) Propulsion	Pressurization He Tank Ozl-2 Burner LO2 Supply Valve LU2 Supply Valve Supply Orifices Supply Orifices Supply Orifices He Solenoid Valve-LU2 He Solenoid Valve-LU2 He Solenoid Valve-LU2 He Check Valves Plennums He Regulator LO2-LE2 Pressure Orifices GH2 Orifice GH2 Check Valve He Pressure Sensor He Temperature Sensor LO2 Tank Pressure Sensor LO2 Tank Pressure Sensor LO2 Tank Pressure Sensor LO2 Tank Pressure Sensor LO2 Tank Pressure Sensor LO2 LU2 Tank Pressure Sensor LO2/LU2 Tank Diffusers LO2/LU3 Tank Diffusers LO2/LU3 Tank Diffusers LO2/LU3 Tank Diffusers LO2/LU3 Tank Diffusers LO2 Abort Pressure Valve Vent/Relief Valve
	Code	33222 3332 3332 3332 3332 3332 3332 33

	Repair Subassy at Depot	××××	*********	< ×	<u>,</u>	· .	
	Rits-Debot Rebeir Ropessy	0.041 0.041 0.514 0.514	0.601 2.043 0.094 0.095 0.062 0.125 0.125 0.125 0.125 0.125 0.125	0.413			
nce.	Subersy Ops Spares	дааа		<b>-</b> -		#* <u>}</u>	. ` .
Maintenance	Repair francompo						
II Ma	Snpessl Reblece	××××	×I	××			
Level	Submesy Failed/ S Fits	0.0031 0.0031 0.0384 0.0384	0.0898	0.0351			
	100 Fits Feiled/ Submesy	0.061 0.061 0.768 0.768	1.795	0.617			
	Component Float Stock (OPS)	-	ен нунанана	<u> </u>	5		
	Component Initial Stock	0	00 0 000000	·		·	
enenc	Repair Tug	·	·				
Maintenance	Replace UMJ/qmcD	×	** * *****	·			
Level I	Failures Per Stts	0.0830	0.0449 0.0449 0.0070 0.0184 0.0094 0.0094 0.0097 0.0097 0.0097				_
	JOO E140 Peilures	1.659	0.898 0.898 0.140 0.367 0.187 0.748 0.191 0.094				
	Number Number	-3 00 00 CK	1	<u>6</u> 9			
	y Level 6 Level 7 Level 6 Level 6 Lessy)		ck Disconnect	·			
	Code - 1.1 Component Level Component Level Assembly Level 6 Functional Equipment (Assembly, Component, Subassy)	ACPS Engine ACPS Module R-UD Axial Thrustor R-LE Tangential Thrustor Thruster Isolation Valve Thruster Chamber Valve	ACPS Support Tank (MeH) Tank (MgOh,) Tank Bladder Relief Valve Burst Disk Ground Check Disconnect Module Isolation Valve Guad Redundant He Valve Fill/Drain Shutoff Valve (He) Fill/Drain Check Valve and Quick Berssure Control Module Shutoff Valve	Pressure Regulator Switch (Pressure			(cont)
	9 <b>9</b> <b>9</b>	4.3.1 4.3.1.2 4.3.1.2 4.3.1.2 4.3.1.2 7.3.1.2 7.3.1.3	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2				<b>3</b> 10 10 10 10 10 10 10 10 10 10 10 10 10

Date 9-4-73

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	Repair Subassy toget	TA TA	
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nce	Sberes Obs Snpessy		
ntenu	Repair Component		
II Mai	Component Replace	×××	
Level II Maintenance	Submesy Failed/ 5 Fits	0.002 0.003 0.001	
	Submesy Failed/ Too Fits	0.003	
	Component Float Stock (OPS)	2 -1	
	Component Initial Stock		
rance	Repair Tug		
1 Maintenance	Seplace UAL/qmoD	××	
Level I	Failures Per 5 Fits	0.1870 0.0992	
	Failures Fer 100 Fits	3.740 1.983	
	Number Per Tug	(3) (1) (2) 5	
	Functional Equipment Subassy)	th ensor e Sensor	
	Code - Arrest	Filter ML Relay DPDT Switch Pressure Sensor Temperature Sensor	
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4	5000	4	0.3396	0.000	0.0005	0.0330	0.0074	0.0001		
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•	TOTAL DEPOT REPALM FOUNT	8		0.000	0.010	0.070	0.030	0.020		
•	MEPAIN MEPAIN MITS BE FOUNT	ğ		0.005	0.005	0.0%	0.030		0.010	
-	TOTAL OPEN SPANSS IN EES	Ç	0.0647	0.000.0	1000.0	0.0330	D.0247	0.0015		
•	SERVE AVVES	CtEBO								
¥	TOTAL OPEN SPARES	7082		30.00	0.002	0.070	0.100	0.300		
2	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ĝ		9.9	0.00	98.0	0.100		0.160	
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-	8008		0.1	11.1	1.2.1	1.3.2	44 44 1	5:1	1.5.1	
	IDENTIFICATION		Structure	Puel Tank Access Gaskets Structure Repair Kits	Oxidizer Tank Access Gaskets Structure Repair Kits	Body Structure Paint Cover Panels, ER Kit	Thrust Structure Repair Kit	Meteoroid Shield	Repair Kit - 3r - Al Repair Kit Fiberglass	

Option 2

£	TOTAL DEPOT SPANES IN EES	ED	0.298
8	TOTAL DEPOT REPAIR KUTS IN EES	C1230i	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8
2	TOTAL DEPOT REPAIR KITS IN EQUIV SUBARSYS	1082	
2	DEPOT REPAIR KITS IN EQUIV SUBASSYS	<b>30</b>	
1,	TOTAL OFER SPARES IN EES	EO	(o. 00533)
ءِ	OPEN SUBASEY SPARES IN EES	C1250	0
1.6	TOTAL OFFR SPARES	1280	
=	OPER SPARES SUBASSY	g	
ū	OPER COMP SPARES IN ESS	P-C -SO	(2) (2) (2) (2) (2) (2) (2) (2) (2) (2)
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٤	TOTAL MITIAL SPANES IN EES	(3)	•
2	MITIAL SUBASSY SPARES IN EES	CIESI	
•	TOTAL MITIAL SPARES SUBABEYS	Ñ	
•	MITIAL SPARES SUBASEYS	118	
^	AVC BURANEY COST AS F RACTION OF ANEY COST	**/C	0.0040
•	MITIAL COMP SPARES IN ESS	118-10-W	<b>s</b> .
•	MITIAL SPARES COMPO NENTS	118	De alt
•	SPARE SPARE COST AS FRACTION OF AREY COST	σ	(10.165)] 0.0146 0.0146 0.0037 0.0037 0.0037 0.0073 0.0073
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IDENTIFICATION	<b>8</b>	A R B B B B B B B B B B B B B B B B B B	SARE COST COST SHIPET	COMP SPANE COST AS FRACTION OF ASSY COST	B SPARES	COMP COMP SPARES IN ESS*	#0E0	MITIAL BPARES SUBABEVS	TOTAL MUTIAL SPARES	MITIAL SUBABEY SPARES IN EES	TOTAL INVTIAL SPARES IN EES	O KA BPANES NEWTS		SAMES	TOTAL OPEN PANES	ONEA SUBASSY SYANES NI CES	TOTAL OPER PARES IN EES	PER PART NAME OF P	TOTAL DEPOT REPAIR EQUIV	TOTAL DEFOT NEAM	TOTAL DEPOT SPANES IN EES	
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Thermal Control	8.0										0						0.495				0.781	
Insulation MLI Repair Kit	2.1.7		6.0	0.21]										3	_ <del>_</del> _	0.238	0.05		8	8.9	0.042	
Insulation Page Liner Repair Kit Vont Valves Regulator Pressure Controller Valves - Solemoid Relief Valve He Bottle	<u> </u>	денана	6.	[c. 79]		·	880.0						·	2300330		88233388	0.03	0.008 0.04 0.04 0.006	6.121	0.539	0.739	
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Option 2

5	TOTAL DEPOT SPARES IN EES	03	0.728										
8	TOTAL DEPOT REPAIR KITS IN EES	C125Di	[0.714] 0.240	0.108	0.158	0.041	0.0005	0.166		 			
61	TOTAL DEPOT REPAIR KITS IN EQUIV SUBASSYS	1,5D,	34.tt	9.		0.045		3.68	) )			 	
•	DEPOT REPAIR KITS IN EQUIV SUBASSYS	ò	1.8 9.2 0.45	88.7.00 8.6.7.00 8.6.7.00	3.5	0.45	2.70	0.38 88.98	·. · · <b>·</b> ·	 	 	 	
-	TOTAL OPER SPARES IN EES	EO	1.359								 		
و	OPER SUBASSY SPARES IN EES	C1250	[0.417] 0.126	0.051	0.0%	0.090	0.030	0.030					
5	OPER TOTAL SPARES SUBASSYS	,SO,	9	##	۵	7		m				 	
:	OPER SPARES SUBASSYS	Š	ผพศ	ผพพพสผ	8	-	٥.	ааа				 	
٤	OPER COMP SPARES IN ESS	R-CrSO								 			
	OPER SPARES COMPO NENTS	ŌS		,							 		
=	TOTAL INITIAL SPARES IN EES	13	0.361								 ,	 . /	
9	INITIAL SUBASSY SPARES IM EES	CIESII	[0.356] [0.026]	0.086					4 j	:			
	TOTAL INITIAL SPARES SUBASEYS	151		<b>-</b>									
•	INITIAL SPARES SUBASSYS	Sir		ноннан									
~	AVG SUBASSY COST AS FRACTION OF ASSV COST	CJ/N4	0.021	0.0037				0.010					
•	INITIAL COMP SPARES IN ESS*	R-CI-Si	0.225	,	0.045		0.015	0.045					
•	INITIAL SPARES COMPO NENTS	lıs	8		٦	0	-	н					
•	SPARE COST AS FRACTION OF ASSY COST	5	[0.264] 0.25	0.30	0.10	0.10	0.10	0.15					
-	SPARE COST COST SHIPSET COST	e	54.0		0.45	8.0	0.15	0.30	· ·		 		
~	NUMBER PER TUG		8	2488%%	N	٦	9	~ <u>ଡଡ</u> େ			•.		Y ILEVEL 6
-	88		3.0 3.1 3.1.1 3.1.1.1 3.1.1.2	33.1.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2	3.1.3	3.1.5	3.1.6	3.1.7 3.1.7.1 3.1.7.2 3.1.7.3				 	ASSEMBL
	IDENTIFICATION		Avionice Data Management Computer Central Processor Memory Stack Electronic Misc (Box R)	Mcd I/F Unit BUU FCU DCU EMU DIU SCU	DOU (m)	/F Unit	Inst Power Supply	System Control Unit FC Board A FC Board B Box Misc					-ESS - EQUIVALENT SHIPSETS OF THE ASSEMBLY (LEVEL 8)

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7	TOTAL DEPOT SPARES IN EES	9			
_		L	_	<u></u>	
1	TOTAL DEPOT REPAIR KITS WEES	C1250	(17.18c) 0.961 0.961	0.153	890.
•	TOTAL GENOT MEPAIN KITS IN EQUIV	-OST	9.4€	2.45	<b>9</b>
•	SABBYBING WEFFIN	9	20.0 10.0 1.8 1.6	2.8 0.45	<b>9.</b>
	TOTAL CPER SPARES IN EES	2			
2	OPER SUBAGEV SPARES IN EES	05:10	0.417	0.188	о. шэ
c	TOTAL OPER SPARES SUBASSYS	Š.	15	m	
•	OPER SPARES BURASSYR	â	ഗ.≄ വ വ	2 4	
13	OPER COMP SPARES IN ESS	9-C-80			
,	OPER SPARES COMPO- NENTS	ğ			
-	TOTAL MITIAL SPARES IN EES	<u>.</u>			
2	MITIAL SUBASSY SPARES IN EES	C1284	0		
•	TOTAL INITIAL SPARES SUBABOYS	Š			
•	MITIAL INITIAL SPARES SPARES SUBASSYS SUBASSYS	ä			
,	SUBARSY COST AS FRACTION OF ASSY COST	<b>2</b>	0.0278	0.0625	
•	MITIAL COMP SPARES IN ESS	A-C-Si	0.900	0.113	
•	SPARES COMPO NENTS	ž	æ	-	00
	COMP SPARE COST AS FRACTION OF ASSY COST	ū	0.182)	0.25	50
,	SPARE COST COMP EMIPSE T		0.45	0.45	0.45
	Marke R PER TUG		<b>୯୬</b> ୦୯୯ ୯	000	
	3006		3.2 3.2.1.2 3.2.1.2 3.2.1.2 3.2.1.2 3.2.1.3	3.2.2.1	3.2.3.2.3.3.1
	IDENTIFICATION		G, N & C Gyra Gyrac Gyrac Accelerometers Sensor Electronics Electronics Electronics Housing Assy & Coolant	Star Tracker Sensor Stabilizer Drive	Lesar Radar Laghts

Option 2

TOTAL TOTAL TOTAL DEPOT DEPOT DEPOT DEPOT DEPOT PRINTS IN RES IN RES		iso, cieso, ED	C1ESD. [0.684]	0.069 0.069 0.069	(11350, (0.684) (0.009 (0.069	0.069 0.069 0.069 0.065 0.065	0.069 0.069 0.065 0.065 0.065 0.006	0.065 0.069 0.069 0.065 0.065 0.065	0.062 0.069 0.069 0.065 0.041 0.041	0.065 0.069 0.065 0.065 0.065 0.086 0.086	0.062 0.069 0.069 0.065 0.041 0.041	0.0684) 0.009 0.006 0.006 0.006 0.006 0.006	0.0684) 0.009 0.069 0.065 0.086 0.086	0.0684) 0.009 0.069 0.065 0.065 0.062 0.041	0.062 0.069 0.065 0.062 0.041	0.062 0.069 0.065 0.062 0.041	0.062 0.069 0.065 0.065 0.041 0.041	0.0684) 0.009 0.069 0.065 0.062 0.041	0.0684) 0.009 0.069 0.065 0.062 0.041	0.0684) 0.069 0.065 0.065 0.062 0.062
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NUMBER S	-	+		a ,n	# , r = <del>2</del>	9T TE	1 (S) (1) t	≠ r r€n r r r t	# 1 (9) (10) 1 10 1 1 t	≠ 1 1€7 T0 1 10T 1 0000	2 7 7 <del>2</del> 7 6 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	4 1 1 <del>2</del>	≠ 1 1€7 T0 1 10J 1 0000	≠ 1 1€7 T0 1 10J 1 0000	≠ 1 1€1 C0 1 10A 1 0000	≠ 1 1 <del>(2)</del> 1 (0) 1 1000 1 10000	≄ । ।€ी ी® । ।®ी । ००००	≄ न न <del>2</del> ते ति® न न®ते न ००००	≠ 1 1€7 T0 1 10J 1 0000	≠ 1 1€7 T0 1 10T 1 0000
<b>30</b> 88			3.3	3.3.1	3.3.2 3.3.2 3.3.2 3.3.3.3 3.3.3.1	3.3.2 3.3.3.2 3.3.3.3 3.3.3.3.3 3.3.3.3.	8.3.1 8.3.2 8.3.3.2 8.3.3.3 9.3.4 4.2.8 8.3.4.1 8.3.4.1			T						T	T TO THE STATE OF	T	T TO THE STATE OF	
IDENTIFICATION			Communications	Communications Omni Antenna RP Multinlexer	Communications Omni Antenna RP Multiplexer Power Amplifier TWT Circuitry	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS PC Board	Communications Omni Antenna RF Multiplexer Power Amplifier Tiver Circuitry Transponder - SGLS RC Board Command Decoder	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS PC Board Command Decoder Processor (Mod/Demod) PC Board Circuitry	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS RC Board Command Decoder Processor (Mod/Demod) RC Board Circuitry RC Board Circuitry RCM Encoder	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS RC Board Command Decoder Processor (Mod/Demod) RC Board Circuitry RCM Encoder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Derive Mech Magnetic Heads Rlectronics	Communications Omni Antenna RF Multiplexer Power Amplifier Circuitry Transponder - SGLS RC Board Command Decoder Processor (Mod/Demod) RC Board Circuitry RTM Encoder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS PC Board Command Decoder Processor (Mod/Demod) PC Board Circuitry PCM Encoder Tape Recorder Tape Recorder Tape Derive Mech Magnetic Reads Electronics	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS PC Board Command Decoder Processor (Mod/Demod) PC Board Circuitry PCM Encoder Tape Recorder Tape Recorder Tape Drive Mach Magnetic Heads Electronics	Communications Omni Antenna RF Multiplexer Power Amplifier TWT Circuitry Transponder - SGLS PC Board Command Decoder Processor (Mod/Demod) PC Board Circuitry PCM Encoder Tape Recorder Tape Recorder Tape Derive Mech Magnetic Heads Electronics	Communications Omni Antenna RF Multiplexer Power Amplifier Tirransponder - SGIS RC Board Command Decoder Processor (Mod/Demod) RC Board Circuitry RCM Encoder Tape Recorder Tape Recorder Tape Drive Mech Magnetic Heads Electronics	Communications Omni Antenna RF Multiplexer Power Amplifier Circuitry Transponder - SGLS RC Board Command Decoder Processor (Mod/Demod) RC Board Circuitry RPA Encoder Tape Recorder	Communications Omni Antenna RF Multiplexer Power Amplifier Circuitry Transponder - SGIS PC Board Command Decoder Processor (Mod/Demod) PC Board Circuitry PCM Encoder Tape Recorder	Communications Omni Antenna RF Multiplexer Power Amplifier Circuitry Transponder - SGIS PC Board Command Decoder Processor (Mod/Demod) PC Board Circuitry PC Board Ci	Communications Omni Antenna RF Multiplexer Power Amplifler Circuitry Transponder - SGLS PC Board Command Decoder Processor (Mcd/Demod) PC Board Circuitry PCM Encoder Tape Recorder Tape Recorder Tape Recorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Ecorder Tape Transponder Tape Recorder Tape Recorder Tape Transponder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Transponder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Recorder Tape Transponder Tape Recorder	Communications Omni Antenna RF Multiplexer Power Amplifier Circuitry Transponder - SGIS RC Board Command Decoder Processor (Mod/Demod) RC Board Circuitry RCM Encoder Tape Recorder Tape Recorder Tape Ectrolics Electronics

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Avionics P 4 of 5

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IDENTIFICATION	3000	TOO TOO	COST COST SWIFET	SPARE COST AS FRACTION OF ASSV COST	SPARES COMPO NENTS	MESS.	9259t	MITIAL SPARES SUBASSYS	INITIAL PARES SUBASEYS	- I	TOTAL INITIAL SPARES IN EES	SPARES COMPO- NENTS		u \$	- 6		SPANES IN EES	445			PARCE STREET
				Ū	<b>3</b>	R-C-Si		ā	181	CIESI	Ē	ē	Q	8	ğ	0 1 1 1	9	ŝ	ğ	0.000	
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ñ	TOTAL DEPOT SPARES IN EES	2						•.
R	TOTAL DEPOT REPAIR KITS IN EES	CIESD	[0.442] 0.039	0.025	0.378	[0.088]		
6	TOTAL DEPOT HEPAIR KITS IN EQUIN	083	1.756	1.410	2.8	1.75		
ă	DEPOT TOTAL REPAIR KITS IN EQUIV EQUIV EQUIV	å S	0.10 0.25 0.006 0.10	00000000000000000000000000000000000000	2.8	1.5	0.25	0.25
:	TOTAL OPER SPARES IN EES	EO			. ,			
٤	OPER SUBASSY SPARES IN EES	C1 250,	0.133	0.450		0.100		
<u>.</u>	TOTAL OPER SPARES SUBASSYS	1057	9	ω		N.		
31	OPER SPARES SUBASSYS	ŝ	QHHHH	нананана		н	٦	-i
l.	OPER COMP SPARES IN ESS	R-C-50;	0.360		0.135			
12	OPER SPARES COMPO- NENTS	Ŝ	N		н			
=	TOTAL INITIAL SPARES IN EES	13						
9	INITIAL SUBASSY SPARES IN EES	C12Sit	0					
-		3. <b>S</b> 11						
•	INITIAL INITIAL SPARES SUBASSYS SUBASSYS	ā						
~	AVG SUBASSY COST AS FRACTION OF ASSY COST	Cj.	0.0222	0.056		0.050		
-	MITIAL COMP SPARES IN ESS	R-C-St	[0.180] 0.180					
•	INITIAL SPARES COMPO NENTS	ž	7	0	,	0		
•	SPARE COST AS FRACTION OF ASSY COST	σ	(0.192] 0.40	0.45	0.15	[0.007]		
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	IDENTIFICATION		Electrical Power Fuel Cells Fuel Cell PP Reactant Control Valve Coupled Regulator Reactant Scrubbers Vent Valves	FC Reactant System O2 Tank B2 Tank C2 Fill Walve O2 Vent/Relief Valve H2 Fill Valve C2 Tank Fresure Gage C2 Tank Fresure Gage	Primary Battery	ution ntion	Components Wire Harnesses Kit	

C-78

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1100   1.0	IDENTIFICATION	8	į	888 888		MUTIAL SPANES		AVG SLEAGEY COST AS	PARES	TOTAL INITIAL SPARES	MITIAL SUBASEY	+	S V V V	+			OPER PUBARY	_		TOTAL DEPOT	TOTAL DEPOT	10TAL DEPO
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Marine   M				4		ā	R-Q-88	, O	ā	1	CIESII	<u>.</u>	ĝ	P-C-BD	â	┢	C1230	2		922	C1280	2
### 1   0.59   0.233   0.685   0.122   ### Feature   1.1.1   1   0.59   0.95   1   0.685   0.122   ### Feature   1.1.1   1   0.59   0.95   1   0.685   0.013   ### Feature   1.1.1   1   1   0.59   0.95   1   0.685   0.013   ### Feature   1.1.1   1   1   1   1   1   1   1   1	Propulsion	0.									86.0	0.183					0.138				0.034	
### Presence   1,11,11   1   1   1   1   1   1   1		1.1		8	[0.213]	•	0.855	;				0.855						(0.647)				(0.158
### Excision		1.1.1		3	3	-	0.02	0.0413				0.162						0.123	G	% %	0.122	
### With Preserve # 1.1.1.4 1	Ĭ.	4.1.1.4 4.1.1.3								,											-	
Solution of August   Augus   August   August   August   August   August   August   August		4.1.1.4													•				.5			
Aday Mail Regime A. Parish Book Mail Regime Possible  17 - 4.1.1.2		1.1.1					,							****	-				9.8			
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tage Reed & FR   1.1.   1   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01   1   0.01		i ;	-						•						н				0.01			
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ank Fresure (1) 15.3 ank Fresu		7.7.	(3)																1.0			
- Tape		7.1.7	3																0.1			
4.1.1.7 - 4.1.1.21 No Maintenance Possible  Mote 1 Main Engine Omitted for Depot.	,	17.3	-												, 4	١,	414		0.1		•	
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Mote 1 Main Engine Omitted for Depot.														`								
Mote 1 Main Engine Omitted for Depot.		-													<del></del> -		···	٠.				
Mote 1 Main Engine Omitted for Depot.											<del></del>											
Mote 1 Main Engine Omitted for Depot.														e e		1						
	Note 1 Main Engine Omit	ted for	Pepot.												<del></del>							

TOTAL DEPOT SPARES IN EES

	589₹	Ĺ	
8	TOTAL DEPOT REPAIN KITS IN EES	C123D	0.0018
2	TOTAL DEPOT REPAIR KITS IN EQUIV SUBAREYS	ÓSI	16.0
=	DEPOT REPAIR KITS IN EQUIV	ğ	0.3 0.0015 0.2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
=	TOTAL OPEN SPARES IN EES	Ĉ,	
2	OPER SUBASSY SPARES IN EES	C1250,	0.0058
2	TOTAL OPER SPARES	Ů.	E
2	OPER SPARES SUBASSYS	ŝ	000000
2	80%=	P-C-50	0.023
2	OPER SPARES COMPO NENTS	ĝ	1
Ŀ	TOTAL INITIAL SPARES IN EES	ū	•
٥	INITIAL SUBASSY SPARES IN EES	C12Si	
•	TOTAL INITIAL SPARES SURASEYS	1.51	
	INITIAL SPARES SUBASSYS	ŝ	
,	AVG SUBASSY COST AS FRACTION OF ASSY OGET	CiAt.	0.0019
•	INITIAL COMP SPARES IN ESS*	R-C-SII	
\$	INITIAL SPARES COMPO NENTS	Sij	0
•	SPARE COST AS FRACTION OF ASSY COST	ď	0.09
	COMP PARE COST : COMP SHIPSE T	æ	51.0
-	NUMBER PER TUG		00000000000000000000000000000000000000
-	80		ASSE 1.2 2.2 2.2 2.2 2.2 2.2 2.2 2.2 2.2 2.2
	IDENTIFICATION		Glmbal Actuators 4.1.2 2  Motor Actuators 4.1.2.1 (4)  Mognetic Clutch 4.1.2.2 (4)  Posicity Transducer 4.1.2.3 (4)  Position Transducer 4.1.2.5 (2)  Ball Screw 4.1.2.6 (2)  Ballows 4.1.2.7 (2)  Case Valve 4.1.2.8 (2)  Case Valve (2)

Option 35

Control of the cont	Option F			2.1									*	ķ.		1.				Propu	Propulsion P	3 of 6
Column   C	,	-		:	•	•	[-	. ~		_	8	=	ب ء	٦	2	ي	•	-			R	-
1	IDENTIFICATION	3000	176 A 7			<del>†                                      </del>					<del></del>			<del></del>					DEPOT REPAIR KITS IN EOUV	TOTAL DEPOT REPAIR KITS IN EQUIV	TOTAL DEPOT REPAIR KITS IN EES	TOTAL DEPOT SPANES IN EES
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2.1.1 (1) 0.99 0.29 0.29 (1) 1.1 (1) 0.99 0.29 (1) 1.1 (1) 0.99 0.29 (1) 1.1 (1) 0.99 0.29 (1) 1.1 (1) 0.99 0.29 (1) 0.2	tain Engine Support	4.2			0.447]	Ī	٥				o	0				٦	_	0.163			┢	0.062
2.1.2 (1) 2.1.3 (2) 2.1.3 (2) 2.1.4 (2) 2.1.4 (2) 2.1.5		4.2.1 4.2 1.1	£,		0.20	·	•	0.033							п		.132		181.0		0.058	
2.2.2.2 (2)	Valve O2 Feed Line Ball	4.2 1.2	3			•			•				· .		਼ ਜ				0.181			
2.2.1 (4) (2.00 0.10 0.007) 2.2.2.1 (4) (2.00 0.10 0.007) 2.2.2.2 (4) (2.00 0.10 0.007) 2.2.2.2 (2.00 0.10 0.007) 2.2.2.3 (2.00 0.10 0.007) 2.2.3.3 (2.00 0.10 0.007) 2.3.4.1 1 0.39 0.10 0.009 2.3.4.2 1 0.39 0.10 0.009 2.3.4.2 1 0.39 0.10 0.009 2.3.4.3 (2.00 0.10 0.007) 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.39 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4.4 1 1 0.30 0.10 0.009 2.3.4 1 1 0.30 0.10 0.009 2.3.4 1 1 0.30 0.10 0.009 2.3.4 1 1 0.30 0.10 0.009 2.3.4 1 1 0.30 0.10 0.009 2.3.4 1 1 0.30 0.10 0.009 2.3.4 1 1 0.30 0.10 0.009 2.3.4 1 1 1 0.30 0.10 0.10 0.10 0.10 0.10 0.1		4.2.1.3 4.2 1.4				00		-	00										0.080.0	គ្ន		
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ĸ	TOTAL DEPOT SPARES IN EES	03	
8	TOTAL DEPOT REPAIR KITS IN EES	CIESD	98.
•	TOTAL DEPOT REPAIR KITS IN EQUIV SUBABSYS	Ó	0.840 (FA)
=	DEPOT REPAIR KITS HE EQUIV SUBASSYS	ā	0.100
Ξ	TOTAL OPER SPANES IN EES	60	
=	OPER SUBASSY SPARES IN EES	C1250,	0.120
=	TOTAL OPEN SPARES	Ŏ Q	4
_	OPER SPARES SUBASEVS	ŝ	aaa a
5	OPER COMP SPARES IN ESS	R-C+30;	
1.2	OPER SPARES COMPO- NENTS	ŝ	
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ō	INITIAL SUBASSY SPARES IN EES	CLESI	
•	TOTAL INITIAL SPARES	iSi.	
-	INITIAL SPARES SURASSYS	ā	000 0
•	AVG SUBASSY COST AS FRACTION OF ASSY COST	į	0.030
	MITTAL COMP SPARES IN ESS*	R-C-St	
	INITIAL SPARES COMPO NENTS	ŝ	000 0
	COMP SPARE COST AS FRACTION OF ASSY COST	σ	0.15
. •	SANE COST	æ	& °
2	NUMBER PER TUG		(2) (1) (1) (1) (2) (3) (4) (4) (4) (5) (6) (7) (6) (7) (7) (7) (7) (7) (7) (7) (7) (7) (7
-	80 DE		4.2. (Cont.d.) 4.2.5.1 (1) 4.2.5.3 (1) 4.2.5.4 (2) 4.2.5.4 (2)
	(DENTIFICATION		Propellant Utilization 4.2.5 [1] Lig Capacitor Probe 4.2.5.1 [1] Log capacitor Probe 4.2.5.3 [1] Asy Capacitor Probe Attach 4.2.5.4 (2) Gackets Gackets Gackets

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Propulsion P 5 of 6

	COMP   COMP   MATTAL   MATTAL   COMP   COM	18-0-88 17	0:30	6.6.9.0 6.6.9.0 7.6.0 7.0.0 7.		102 4.2.6.7			ខ្លុំជ	Months of the control			,	Me freez, semisor 9.2.0. 1	Burner Temp. Sensor A.2.6. 1	5	102 Tank Press Sensor 4.2.6. 2	102/12 Tenk Diff. 4.2.6. 2	Mo Abort Press Valve 4.2.6. 2	Vent/Relief Valve 4 2.6. 1						
•	AVG MITTAL MITTAL COST AS PARES MATERIAL FACTION BARABYIS MARSHYS COST ASSY BARABYIS MARSHYS	1821 CAMP. SEC.	9800.0		· · · · ·															<u> </u>		···				
2	SUTIAL SURABIV WANES HEES	C1281 EI												1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1							1.		. <u>-</u>	٠.		
13	OPER AL SPARES AL SPARES BE COMPO- ES NEWTS	ĝ				z.							-													
13 14	OPER OPER COMP SPARES SPARES IN ESS SUBARY	P-C)-BDI	· ·					ş* ·				- '						<del>-</del> ,							5.	
. 18	RES OFFR OFFR SPARES STANDES	-081	61																							
1,	GPEN TOT SUBAREY OF SPARES SPA IN EES IN I	C1250- E0	0.163																					-		
	DEPOT ONEA REFAIR SPANES KITS IN EQUIV	ģ	<b>y</b>	0.00	0.125	0.125	0.060	0.023	2	· · · · · · · · · · · · · · · · · · ·	9	0.0 0.0	2 6	3.50		3.900	3.900		0.180	0.600						
	TOTAL DEPOT MEPAIR KITS NO EQUIV	5	n.93 o.		<u> </u>		(£	<b>£</b>	 i	<b>5</b> 2	<u> </u>		5 2	\$ <b>\$</b>	\$	ដ	¥	¥1		,				<del></del>		
	TOTAL TOTAL DEPOT DEPOT BEAUS HITS IN EES	C12501 ED	0.108					<del></del> .			·															

٦	TOTAL DEPOT SPARES IN EES	8	0.0007	0.251													]
	TOTAL DEPOT REPAIR SINEES	_	0.014] 0.014	[0.8½0] 0.131 0.131	88	0.00 0.018 0.008 0.008	0.00 400.0	0.207			<del></del>		0.225	 		<del></del> -	 1
	DAMES			9000		33333	<u>.</u>	ö						 <del></del>	<del></del>	<u></u> -	 4
2	TOTAL DEPOT REPAIR KITS IN EQUIV SUBASEYS	ŌSZ	1.110	ŧ							_	~~	គ្ន	 			
=	DEPOT REPAIR KITS IN EQUIV SUBASSYS	ō,	0.0 140.0 141.	0.514 0.601 0.601	1000 1000 1000 1000 1000 1000 1000 100	0.246 0.125 0.125 0.063	0.122	1.139	(69₩.0	(0.413)	(0.005)	9.0	8.340				
=	TOTAL CPER SPARES IN EES	EO	0.046	0.277													
9	OPER SUBASSY SPARES IN EES	C1130	0.050	[0.007]	0.00									 			
18	TOTAL OPER SPARES SUBASSYS	ÖS	52 L		4												
=	OPER SPARES SUBASSYS	ŝ	10.952	ä	4` A												
[ 2	OPER COMP SPARES IN ESS	9-C+SO	6.0 <del>)</del>	[0.92] 0.196 0.198	0.016	0.08 0.038 0.131 0.038	0.032	0.164					0.049				
~	OPER SPARES COMPO NENTS	ã	1	44	7		7	н					2 1				
=	TOTAL INITIAL SPARES IN EES	=	o	0						*							
2	INITIAL SUBASSY SPARES IN EES	C12Sii	o	0													
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•	INITIAL SPARES SUBASSYS	ā										<del>.</del>		 			
,	AVG SUBASSY COST AS FRACTION OF ASSY COST	į	0.0125	8	0.00			0.0096									
<b>[</b> -	MITIAL S SORES SPARES IN ESS	3.05.E	0	•	, 0						-						 1
ء	₹8 0°E	ā											•.				1
•	SPARE COST AS FRACTION OF ASSY COST	σ	[0.048] 1.0	[0.299] 0.218 0.218	0.018	0.027 0.036 0.145 0.036	9.036	0.182					0.057		•		
~	SARE COST T SOS		0.225	6.0				<u> </u>					0.180	 			
~	NUMBE R		3 8 8 E	3 (3)	v w.E	~ ~ ~ ~ ~	٦	<b>1</b> (€)	(3)	(9)	(3)	3	12(2)				REVEL 61
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	IDENTIFICATION		ACPS Eng. ACPS Mod 4.3.1 R-4D Auxiliary Thruster 4.3.1. R-1E Tang. Thruster 4.3.1.	a).ve	Relief Valve	Check Disconnect Drain & Disc olation ed He Valve rain S/O Valve	rain Check Valve	(ne)  He Pressure Control Mod 4.4.10 S/O Valve	Pressure Regulator	Pressure Switch	Filter	M. Relay	Pressure Sensors Temperature Sensors				ESS EQUIVALENT SHIPSETS OF THE ASSEMBLY (LEVEL 6)

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# Appendix D - Task Description Sheets

This appendix contains the baseline time line encompassing all operations for all options and the associated task description sheets. These were used to develop the specific option time lines presented in section 11.3.6.

MDAC CRYOGENIC TUG STUDY

TASK DESCRIPTION SHEETS

9 JULY 1973

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ASK OBJECTIVE: To s				<u> </u>
DK 10111000.	construct an M&R sche			
aintenance records	and integration of s	ubsystem schedul	ed nan requi	.rements
				<u>,</u>
			<u>.</u>	
		4	·	<u> </u>
ASK LOCATION: TPF	/KSC and PPF/WTR			
ASK EQUIPMENT:				
	he Met Most Cot			•
	ta Mgt Test Set			
	Cable Kit (Partial)			
148 <u>Si</u>	gnal Conditioning Uni	t (Partial)		
———			·	
			<del></del>	
MANPOWER REQUIREMENT			M-HRS	
	MECHANICAL TECH AVIONICS TECH	0	M-HRS	
	ENGINEERING	16	M-HRS	
	QUALITY CONTROL	3	M-HRS	
	SAFETY	3	M-HRS	
	OTHER	0	M-HRS	
INTERFACE REQUIREME	NTC.			

+ 0-8

MSK ITILE:		TELEMETRY DATA FO			(1.1.4)	
TASK OBJECTIVE: 💆	o iden	tify unscheduled M	&R require	ments.		. *
				٨		
	,					
TASK PURPOSE:	To anal	yze TM data to ide	entify infl	ight an	omalies o	ccurring
during the last	Tug mis	sion. Fault isola	te to LRU	and def	ine unsch	eduled
M&R requirements			*			4
		v.		, ^		
	<u></u>					
<u></u>	· · · · · · · · · · · · · · · · · · ·				<del> </del>	:
			<u>,, </u>	<u></u>		
		ʻ.				
TASK LOCATION:	TPF/KS	and PPF/WTR				
TASK EQUIPMENT:	Hard C	opy Via Ground Sta	tions		· · · · · · · · · · · · · · · · · · ·	•
		try Ground Station		^		
128	Teleme	ory oromic ovacro.				
• .			<u> </u>			
•						
			•	•		
MANPOWER REQUIRE	MENTS.	PROPULSION TECH		0	M-HRS	
PHILDREK KEGOTKE	riciti J .	MECHANICAL TECH _		0	M-HRS	
		AVIONICS TECH	s.	0	M-HRS	
4.2°		ENGINEERING		18	M-HRS	
	• ,	QUALITY CONTROL	· · · · · · · · · · · · · · · · · · ·	6	M-HRS	
	1	SAFETY _	·	6	M-HRS	
-		OTHER	<u> </u>	8	M-HRS	
INTERFACE REQUIR	EMENTS:	Software progra	m to proce	ess TM d	ieta	
3 · · · · · · · · · · · · · · · · · · ·						

	FE M&R SCHEDULE (1.1.3)			
SK OBJECTIVE: To e	stablish an integrated	M&R schedule.		
	· .			
				<del>,",</del>
ASK PURPOSE: To 1	ntegrate scheduled and	unscheduled M&R	requireme	nts.
			· · · · · · · · · · · · · · · · · · ·	<u> </u>
N. Carlotte				
		·	<u></u>	
				·
		· •		
ASK LOCATION: TPF	/KSC and PPF/WTR		· .	
				* * * * * * * * * * * * * * * * * * *
127 <u>Da</u>	ta Mgt Test Set			
· .			<del></del>	
			· · · · · · · · · · · · · · · · · · ·	
MANPOWER REQUIREMENT	S: PROPULSION TECH	0	M-HRS	
THE CHEST THE COURT OF THE COUR	MECHANICAL TECH	0	M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	14	M-HRS	
	QUALITY CONTROL	<u> </u>	M-HRS	
	SAFETY	<u> </u>	M-HRS M-HRS	
	OTHER	0		
INTERFACE REQUIREMEN	ITS:			<del></del>

MOR IIIICI		TUG AT TPF/PPF							
ASK OBJECTIVE: To	o phys	cally enter t	the Tug	into M	&R cy	cle.	This 1	ask t	ınd
subsequent tasks	conside	er (1) New Tug	gs, (2)	Tugs f	rom P	ost	Landing	Opera	tions
and (3) Tugs from	Stora	ge.							
		`						· · · · · · · · · · · · · · · · · · ·	
TASK PURPOSE: T	o plac	e the Tug in :	its M&R	posit:	ion at	the	TPF/PP	Fand	assur
a final safe cond									
B 11mm bare out									
									,
						····			
· · · · · · · · · · · · · · · · · · ·									
TASK LOCATION:	rpf/ksc	and PPF/WTR							
_			1.0						
TASK EQUIPMENT:		-							
124		ės	<del>++</del>						
183	Trans	porter							
							<u> </u>		
								•	
MANPOWER REQUIREM	ENTS.	PROPULSION T	FCH		0		M-HRS		
MANPOWEK REQUIREM	ENIJ.	MECHANICAL T		·	3		 M-HRS		
		AVIONICS TEC			0		M-HRS		
		ENGINEERING			0		M-HRS		
		QUALITY CONT	ROL		0		M-HRS		
		SAFETY	-		1.5		M-HRS M-HRS		
		OTHER		·	<u> </u>		M-UM	•	
INTERFACE REQUIRE	MENTS:								

K TITLE: PREPARE FOR INSPECTION AND CHECK	ion for I	Post Flight/Receiving	
K OBJECTIVE: To place the Tug in a condit	101 101		
spection and C/O			
SK PURPOSE: To position workstands, prov	ride acce	ess to installed subsystems	
nd connect/checkout GSE.			
	121	Comsec Equipment	
	191	Workstand Kit	
	175	Static Dessicant Kit	
	111	APS Breakout Control Box	
	117	Checkout Access Kit	
ASK LOCATION: TPF/KSC and PPF/WTR			
ASK EQUIPMENT: 168 Spacecraft Simulator	169	Space Tug Simulator	
124 Cradles	148	Signal Cond Unit	
183 Transporter	155	Power Sys Test Set	
118 Checkout Cable Kit	161	Prop Pneumatic Console	
119 Comm Test Set	163	Propellant or Pneumatic Console	nt
127 Data Mgt Test Set		Consore	
185 Umbilical Kit	149	Orbiter Simulator	
MANPOWER REQUIREMENTS: PROPULSION TECH		O M-HRS	
MANPOWER REQUIREMENTS: PROFOSOS TECH		22.5 M-HRS	
AVIONICS TECH		O M-HRS	
ENGINEERING		O M-HRS	
QUALITY CONTROL		O M-HRS	
SAFETY		O M-HRS	
OTHER		O M-HRS	
INTERFACE REQUIREMENTS:			
		•	

		rmine subsystem physics status where instr			
ntegrity and sub	system	Status where Instr			
	·				
NSK PURPOSE:	o ider	ntify unscheduled M&	R requirements no	ot previously	
dentified.					
			V		
<del></del>					
· 				·	
ASK LOCATION:	TPF/KS	C and PPF/WTR			
ASK EQUIPMENT:	124	Cradles			
•	183	Transporter	·	·	
	191	Workstand Kit		· ·	
	<u> </u>	WOLKS GALLET			
				<del></del>	
	· ·				
				, 	
				<del></del>	
MANPOWER REQUIREM	ENTS:	PROPULSION TECH	24	M-HRS	
•		MECHANICAL TECH	24	M-HRS	
		AVIONICS TECH	8	M-HRS	
		ENGINEERING	20	M-HRS	
a service de la companya de la compa		QUALITY CONTROL	16 0	M-HRS M-HRS	
		SAFETY	0	M-HRS	
		Alury			

ISK TITLE:	PERFORM	POST FLIGHT C/O 11	111 1110			
SK OBJECTIVE:	To dete	ermine Main Propulsion	Status	•		
		ify functional integri	tv and	interface	of main pro	pulsi
ASK PURPOSE: _	To ver	ify functional integri	0, 4	to ealth	rote transduc	ers.
components, ver	ify our	ges, perform leak chec	ks and	to carro	ace cransaa	
			<u></u>			<del></del>
					·	
TASK LOCATION:	TPF/K	SC and PPF/WTR				
TASK EQUIPMENT:	124	Cradles	148	Signal	Cond Unit	
	183	Transporter	185	Umbilic	al Kit	
	191	Workstand Kit	161	Prop Pn	eumatic Consc	le
	118	Checkout Cable Kit	117	C/O Acc	ess Kit	
		Data Mgt Test Set	180	Environ	Cooling	
	127					
	<u>119</u> .	Comm. Test Set				
	155	Power Sys Test Set				
MANPOWER REQUIT	REMENTS			16	M-HRS	
		MECHANICAL TECH		8.5	M-HRS M-HRS	
		AVIONICS TECH		8.5	M-NRS	
		ENGINEERING		8.5	M=HRS	
		QUALITY CONTROL		0.5	M-HRS	
		SAFETY		0	M-HRS	
		OTHER				

er objective.	To def	ermine Main Propulsi	on Status		- COLD He PRESS. (1.1
OK OBSECTIVE:	10 20				
	<del></del>		<u> </u>		
		<u> </u>	**	·	
ASK PURPOSE: _					ce of main propulsion
components, ver	ify pu	rges, perform leak ch	ecks, and	i to cal	ibrate transducers.
				<del></del>	
:		<u>. ' </u>	2.1 × 2		
				:	
<del> </del>	<del></del>				
	<del></del>				e Carlo
		ac 1 ppg/smp			
TASK LOCATION:	TPF/K	SC and PPF/WTR	·		
TASK EQUIPMENT:	124	Cradles	148	Signal	Cond Unit
	183	Transporter	185	Umbili	cal Kit
	191	Workstand Kit	161	Prop P	neumatic Console
	118	Checkout Cable Kit	117_	C/O Ac	cess Kit
•	127	Data Mgt Test Set	180	Enviro	n Cool Unit
	119	Comm Test Set	163		lant or Pneumatic
<u>.</u>				Con	tro <del>l-Con</del> sole
	155	Power Sys Test Set			
MANPOWER REQUIRE	EMENTS			0	M-HRS M-HRS
•		MECHANICAL TECH		8.5	M-HRS
		ENGINEERING		8.5	M-HRS
		QUALITY CONTROL	<del> </del>	8.5	M-HRS
		SAFETY		0	M-HRS
		OTHER		0	M-HRS

K   1   LE:		4 POST FLIGHT C/O - MA			TO LOOM THE BOOK LAND
K OBJECTIVE:	To det	ermine Main Propulsion	Status		
				interfece	of main propulsion
ASK PURPOSE: _	To ver	ify functional integri	ty and	the endit	rete transducers.
components, ver	ify pur	ges, perform leak chec	eks, and	to carre	rate transduction
			, <u></u>		
	,				
TARK LOCATION.	трг/к	SC and PPF/WTR			
TASK LOCATION:		Cradles	148	Signal (	Cond Unit
TASK EQUIPMENT:	183	Transporter	185	Umbilica	al Kit
			161		eumatic Console
	191	Workstand Kit			
	118	Checkout Cable Kit	117	C/O Acc	<del></del>
	127	Data Mgt Test Set	180		Cool Unit
	119	Comm Test Set	163	Prop or	Pneumatic Control Cons
	155	Power Sys Test Set			
MANPOWER REOUI	REMENTS	: PROPULSION TECH		17	_ M-HRS
		MECHANICAL TECH		0	M-HRS
		AVIONICS TECH		8.5	M-HRS
		ENGINEERING		8.5	_ M-HRS
		QUALITY CONTROL		0.5	M-HRS
	,	SAFETY		0	M-HRS
		OTHER		U	M-HRS

-9-D-/W

K OBJECTIVE:	To det	ermine Main Propulsion	n Status	3. · · · ·	·	
· .	<u> </u>			·	`	
			,		·	
SK PURPOSE:	To ver	ify functional integr	ity and	interfac	e of main	propulsio
omponents, ver	ify our	ges, perform leak che	cks and	to calib	rate trans	ducers.
					·	
		<del></del>				
<del></del>						
ASK LOCATION:	TPF/K	SC and PPF/WTR	<del> </del>			
ASK EQUIPMENT:	124	Cradles	148	Signal (	Cond Unit	· · · · · · · · · · · · · · · · · · ·
	183	Transporter	185	Umbilica	al Kit	
	191	Workstand Kit	161	Prop Pne	eumatic Co	nsole
	118	C/O Cable Kit	117	C/O Acc	ess Kit	
	127	Data Mgt Test Set	180	Environ	Cool Unit	•
	119	Comm Test Set	163	Prop or	Pneumation	Control
		Power Sys Test Set				
	155				M 1100	
MANPOWER REQUIR	EMENTS:	PROPULSION TECH MECHANICAL TECH	<u></u>	16 0	_ M-HRS M-HRS	
		AVIONICS TECH		8	M-HRS	
		ENGINEERING		8	M-HRS	
		QUALITY CONTROL		8	M-HRS	
•	•	SAFETY		0	_ M-HRS	
		OTHER		0	M-HRS	
		5:			<del>-</del>	

SK OBJECTIVE: _	ro det	ermine APS status.			
ASK PURPOSE:	To ver	rify functional integr	ity and	interface	of APS compon
perform leak che					
Jerrora Took	<u></u>				
				*	
					<u> </u>
	· · · · · · · · · · · · · · · · · · ·				
TASK LOCATION:	TPF/K	SC and PPF/WTR	<del> </del>		
TASK EQUIPMENT:	124	Cradles	161	Prop Pneu	matic Console
	183	Transporter	127	Data Met	<u>Test S</u> et
	191	Workstand Kit	119	Comm Test	Set
1		Prop or Pneu Contr.Co	ns.155	Power Sys	Test_Set
	111	ACPS Breakout Box	148	Signal Co	nd Unit
			185	Umbilical	
	117	C/O Access Kit			
	118	C/O Cable Kit	180		
MANPOWER REQUIRE	EMENTS		<del></del>	0	_ M-HRS M-HRS
		MECHANICAL TECH AVIONICS TECH		7	M-HRS
		ENGINEERING		7	M-HRS
		QUALITY CONTROL		7	M-HRS
		SAFETY		0	M-HRS
		OTHER		0	M-HRS
		OTHER		<del></del>	

K OBJECTIVE:	ro dece	ermine APS status.			1.1
			<u> </u>	<u> </u>	
			<u> </u>		
		with the second			
SK PURPOSE:	To ver:	ify functional integr	ity and	interface	s of APS compone
d perform leak		•			
d periorm lean	CHOCK				
				·	
			·		
				•	
ASK LOCATION:	TPF/KS	SC and PPF/WTR			
		Cradles	161	Prop Pneu	matic Console
ASK EQUIPMENT:	124			7	
	183	Transporter	127	Data Mgt	
	191	Workstand Kit	119	Comm Test	Set
	163	Prop or Pneumatic Control Console	155	Power Sys	Test Set
	111	ACPS Breakout Box	148	Signal Co	nd Unit
÷	117	C/O Access Kit	185	Umbilical	. Kit
	118	C/O Cable Kit	180	Environ (	Cool Unit
				26	M-HRS
MANPOWER REQUIREMENTS:			<del></del>	0	_ M-HRS
		MECHANICAL TECH AVIONICS TECH		13	M-HRS
•		ENGINEERING		13	_ M-HRS
	æ	QUALITY CONTROL		13	M-HRS
	,	SAFETY	Y	0	_ M-HRS
		OTHER		. 0	_ M-HRS

	o ucoc	rmine APS status.			
				· · · · · · · · · · · · · · · · · · ·	
	'o wer	ify functional integr	ity and	interface	of APS
omponents and pe					
mponents and be	FIOIM	Tem Charles			
	<del></del>				
	· 				
			,		
ASK LOCATION:	TPF/K	SC and PPF/WTR			
ASK EQUIPMENT:	124	Cradles	161	Prop Pneu	matic Console
	183	Transporter	127	Data Met	Test Set
	191	Workstand Kit	119	Comm Test	Set_
	163	Prop or Pneumatic	155	Power Sy	s Test Set
		Control Console  ACPS Breakout Box	148	Signal C	
	111		185_	Umbilica	
	117	C/O Access Kit			
	118	C/O Cable Kit	180		Cool Unit
MANPOWER REQUIR	EMENTS			26	_ M-HRS
		MECHANICAL TECH		0	_ M-HRS
		AVIONICS TECH		13	M-HRS
•		ENGINEERING		13	M-HRS
•				13	M-HRS
•		QUALITY CONTROL			
		QUALITY CONTROL		0	M-HRS M-HRS

TASK OBJECTIVE: To determine APS status  TASK PURPOSE: To verify functional integrity and interface of APS command perform leak checks, inspect turbo pump bearings and shaft torques  TASK LOCATION: TPF/KSC and PPF/WTR  TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol 183 Transporter 127 Data Mgt Test Set 191 Workstand Kit 119 Comm Test Set Prop or Pneumatic 163 Control Console 155 Power Sys Test Set 111 ACPS Breakout Box 148 Signal Cond Unit 117 C/O Access Kit 185 Umbilical Kit 118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS MECHANICAL TECH 0 M-HRS AVIONICS TECH 16 M-HRS ENGINEERING 16 M-HRS	
TASK PURPOSE: To verify functional integrity and interface of APS compand perform leak checks, inspect turbo pump bearings and shaft torques  TASK LOCATION: TPF/KSC and PPF/WTR  TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol 183 Transporter 127 Data Mgt Test Set 191 Workstand Kit 119 Comm Test Set Prop or Pneumatic 163 Control Console 155 Power Sys Test Set 111 ACPS Breakout Box 148 Signal Cond Unit 117 C/O Access Kit 185 Umbilical Kit 118 C/O Cable Kit 180 Environ Cool Unit MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS MECHANICAL TECH 0 M-HRS AVIONICS TECH 16 M-HRS ENGINEERING 16 M-HRS	
TASK LOCATION: TPF/KSC and PPF/WTR  TASK EQUIPMENT: 124	
TASK LOCATION: TPF/KSC and PPF/WTR  TASK LOCATION: TPF/KSC and PPF/WTR  TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol 183 Transporter 127 Data Mgt Test Set 191 Workstand Kit 119 Comm Test Set 191 Workstand Kit 119 Comm Test Set 163 Control Console 155 Power Sys Test Set 111 ACPS Breakout Box 148 Signal Cond Unit 117 C/O Access Kit 185 Umbilical Kit 118 C/O Cable Kit 180 Environ Cool Unit 118 C/O Cable Kit 180 Environ Cool Unit MECHANICAL TECH 0 M-HRS AVIONICS TECH 16 M-HRS ENGINEERING 16 M-HRS	
TASK LOCATION: TPF/KSC and PPF/WTR  TASK LOCATION: TPF/KSC and PPF/WTR  TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol 183 Transporter 127 Data Mgt Test Set 191 Workstand Kit 119 Comm Test Set 191 Workstand Kit 119 Comm Test Set 163 Control Console 155 Power Sys Test Set 111 ACPS Breakout Box 148 Signal Cond Unit 117 C/O Access Kit 185 Umbilical Kit 118 C/O Cable Kit 180 Environ Cool Unit 118 C/O Cable Kit 180 Environ Cool Unit MECHANICAL TECH 0 M-HRS AVIONICS TECH 16 M-HRS ENGINEERING 16 M-HRS	
TASK LOCATION: TPF/KSC and PPF/WTR  TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol 183 Transporter 127 Data Mgt Test Set 191 Workstand Kit 119 Comm Test Set 191 Workstand Kit 119 Comm Test Set 163 Control Console 155 Power Sys Test Set 111 ACPS Breakout Box 148 Signal Cond Unit 117 C/O Access Kit 185 Umbilical Kit 118 C/O Cable Kit 180 Environ Cool Unit 117 C/O Cable Kit 180 Environ Cool Unit 118 C/O Cable Kit 180 Environ Cool Unit 119 MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS MECHANICAL TECH 0 M-HRS AVIONICS TECH 16 M-HRS ENGINEERING 16 M-HRS	poner
TASK LOCATION:   TPF/KSC and PPF/WTR	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
TASK EQUIPMENT: 124 Cradles 161 Prop Pneumatic Consol  183 Transporter 127 Data Mgt Test Set  191 Workstand Kit 119 Comm Test Set  163 Control Console 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
Prop or Pneumatic 163 Control Console  111 ACPS Breakout Box 148 Signal Cond Unit 117 C/O Access Kit 185 Umbilical Kit 118 C/O Cable Kit 180 Environ Cool Unit MANPOWER REQUIREMENTS: PROPULSION TECH AVIONICS TECH ENGINEERING 16 M-HRS ENGINEERING 16 M-HRS	le
Prop or Pneumatic 155 Power Sys Test Set  111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
111 ACPS Breakout Box 148 Signal Cond Unit  117 C/O Access Kit 185 Umbilical Kit  118 C/O Cable Kit 180 Environ Cool Unit  MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  180 Environ Cool Unit  32 M-HRS  M-HRS  M-HRS  M-HRS	
MANPOWER REQUIREMENTS: PROPULSION TECH 32 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
MECHANICAL TECH 0 M-HRS AVIONICS TECH 16 M-HRS ENGINEERING 16 M-HRS	
MECHANICAL TECH 0 M-HRS  AVIONICS TECH 16 M-HRS  ENGINEERING 16 M-HRS	
ENGINEERING 16 M-HRS	
FUOTIFETITIO	
QUALITY CONTROL 16 M-HRS	
SAFETY O M-HRS	
OTHER OM-HRS	
INTERFACE REQUIREMENTS:	

TASK OBJECTIVE:		ermine avionics status		·	***
TASK PURPOSE: _	To ver	ify functional integri	ty and	interfa	ce of avionics
components and p	erform	required calibration	· · · · · · · · · · · · · · · · · · ·		
			156	Prim B	att C/O Kit
	TPF/KS	SC and PPF/WTR	121		Equipt
TASK LOCATION:			148		Cond Unit
TASK EQUIPMENT:	124	Cradles			
304, 307	183	Transporter	169	·····	mulator_
ware	191	Workstand Kit	144		Radar C/O Kit
uter rams	118	Cable Kit	168		raft Simulator
	119	Comm Test Set	174	Star T	racker Sim
	127	Data Mgt Test Set	149	Orbite	r Simulator
	155	Power Sys Test Set	180	Fnviro	n Cool Unit
MANPOWER REQUIRE	EMENTS:	PROPULSION TECH		0	M-HRS
		MECHANICAL TECH	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	0	M-HRS
		AVIONICS TECH		48.5	M-HRS
		ENGINEERING		69	M-HRS
		QUALITY CONTROL		10	M-HRS
		SAFETY		0	M-HRS
		OTHER		0	M-HRS

mponents, verify purges, perform leak check  SK LOCATION: TPF/KSC and PPF/WTR	y and	interface to calibr	ate transducers
SK LOCATION: TPF/KSC and PPF/WTR  SK EQUIPMENT: 124 Cradles  183 Transporter	and	to calibr	ate transducers
ASK LOCATION: TPF/KSC and PPF/WTR  ASK EQUIPMENT: 124 Cradles  183 Transporter	and	to calibr	ate transducers
ASK LOCATION: TPF/KSC and PPF/WTR  ASK EQUIPMENT: 124 Cradles  183 Transporter	and	to calibr	ate transducers
ASK LOCATION: TPF/KSC and PPF/WTR  ASK EQUIPMENT: 124 Cradles  183 Transporter	and	to calibr	ate transducers
ASK LOCATION: TPF/KSC and PPF/WTR  ASK EQUIPMENT: 124 Cradles  183 Transporter	148	Signal C	cond Unit
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
ASK EQUIPMENT: 124 Cradles  183 Transporter			<del></del>
183 Transporter			<del></del>
	185	Imbilice	7 172 4
191 Workstand Kit		OMOTITICA	I KIT
	161	Prop Pne	eumatic Console
118 Checkout Cable Kit	117	C/O Acce	ess Kit
	180	Environ	
		111111111111111111111111111111111111111	
119 Comm Test Set			<del></del>
155 Power Sys Test Set			<del></del>
MANPOWER REQUIREMENTS: PROPULSION TECH			_ M-HRS
MECHANICAL TECH	<del> </del>	0	_ M-HRS
AVIONICS TECH		30	_ M-HRS
ENGINEERING		30	_ M-HRS
QUALITY CONTROL		30	_ M-HRS
SAFETY		0	_ M-HRS
OTHER		0	_ M-HRS
INTERFACE REQUIREMENTS:			_

	•	OST STORAGE C/O - MAIN			
ISK OBJECTIVE: _	To det	ermine Main Propulsion	n Status	<u> </u>	
	<del></del>		<u></u>		
					. A Main Duamulai
		ify functional integr			
components, ver	ify pur	ges, perform leak che	cks and	to calib	rate transducers.
	· · · · · · · · · · · · · · · · · · ·				
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TASK LOCATION:	TPF/K	SC and PPF/WTR			
TASK EQUIPMENT:	124	Cradles	148	Signal C	ond Unit
INDIC EQUITATION	163	Transporter	185	Umbilica	1 Kit
	191	Workstand Kit	161	Prop Pne	eumatic Console
	118	Checkout Cable Kit	117	C/O Acce	ess Kit
	127	Data Mgt Test Set	180	Environ	Cool Unit
•	119	Comm Test Set	163	Prop or	Pneumatic Control Console
	155	Power Sys Test Set			
MANPOWER REQUIR				68	M-HRS
MANPONEK KEQUIK	CIJENI J	MECHANICAL TECH		0	_ M-HRS
		AVIONICS TECH		34	_ M-HRS
		ENGINEERING		34	_ M-HRS
		QUALITY CONTROL		34	_ M-HRS
		SAFETY		0	_ M-HRS
		OTHER		0	_ M-HRS

K OBJECTIVE:	ro dete	ermine Main Propulsion	Status			
		ify functional integri		*		
mponents, veri	fy pur	ges, perform leak chec	ks to	alibrate	transducers.	<del></del>
				<u> </u>		
					`	
					·	***************************************
			•		` ·	
SK LOCATION:	TPF/KS	C and PPF/WTR				
ISK EQUIPMENT:	124	Cradles	148	Signal	Cond Unit	
	183	Transporter	185	Umbilic	al Kit	
	191	Workstand Kit	161	Prop Pn	eumatic Consc	le
	118	Checkout Cable Kit	117	C/O Acc	ess Kit	
	127	Data Mgt Test Set	180	Environ	Cool Unit	
4	119	Comm Test Set	163	Prop or	Pneumatic Co Console	ntrol
	155	Power Sys Test Set			· .	
ANPOWER REQUIRE			<u>,,,, p. 7. 2 7 2, i i 7 1</u>	54	M-HRS	
ARPONER REQUIRE		MECHANICAL TECH		0	_ M-HRS	
•		AVIONICS TECH		27	M-HRS	
		ENGINEERING		27	_ M-HRS	
		QUALITY CONTROL		27	_ M-HRS	* ,
		SAFETY		0	_ M-HRS	
		OTHER		0	_ M-HRS	
NTERFACE REQUI	REMENTS					

SK OBJECTIVE: _	To det	ermine Main Propulsion	Status			<del></del>
						**************************************
ASK PURPOSE: _		rify functional integr			7	
components, veri	fy pur	ges, perform leak che	cks, and	i to cal	ibrate t	ransducers
						:
					<del>له معدود معا با معاد کی کی پی</del>	
						· .
ASK LOCATION:	TPF/K	SC and PPF/WTR	· <del></del>		<del> </del>	
ASK EQUIPMENT:	124	Cradles	148	Signal	Cond Un	it
	183	Transporter	185	Umbili	cal Kit	
	191	Workstand Kit	161	Prop P	neumatic	Console
	118	C/O Cable Kit	117	C/O Ac	cess Kit	
•	127	Data Mgt Test Set	180	Enviro	n Cool U	nit
	119	Comm Test Set	163	Prop o	r Pneuma	tic Contro Console
	4					COMBOLC
·	155	Power Sys Test Set	,		. м пос	
ANPOWER REQUIRE	MENTS:	PROPULSION TECH		<u>52</u> 0	M-HRS M-HRS	
	ų	MECHANICAL TECH AVIONICS TECH		26	M-HRS	
		ENGINEERING		26	M-HRS	
		QUALITY CONTROL		26	M-HRS	
		SAFETY		0	_ M-HRS	
		OTHER		0 🖟	M-HRS	
NTERFACE REQUIR	EMFNTS	: :				

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						:
SK PURPOSE:	To verii	y functional integr	ity and	interface	of APS com	onen
erform leak che	cks					
				·		
					<u></u>	
					·	
ASK LOCATION:	TPF/KSC	and PPF/WTR				
		Cradles	161	Prop Pne	umatic Cons	ole
rask equipment:			127	Data Mat	<u> mest</u> Set	
		Transporter	119	Comm Tes		
		Morkstand Kit Prop or Pneumatic			's Test Set	
•	163	Control Console	155			
	111	ACPS Breakout Box	148	Signal (	Cond Unit	
·	117_	C/O Access Kit	185	Umbilice	al Kit	•
	118	C/O Cable Kit	180	Environ	Cool Unit	
		PROPULSION TECH		22	M-HRS	
MANPOWER REQUIRE	EMEN13.	MECHANICAL TECH		0	M-HRS	
	•	AVIONICS TECH		11	_ M-HRS	
•		ENGINEERING		11	_ M-HRS	
		QUALITY CONTROL		11	_ M-HRS	
		SAFETY		0	_ M-HRS	
		OTHER		0	M-HRS	

SK OBJECTIVE: _T	o deter	mine APS status			
JK 10.0. 002.		fy functional integrit	y and i	nterface	of APS componen
nd perform leak	cnecks				
	<u>:</u>		*		
				:	
				· · · · · · · · · · · · · · · · · · ·	
	· · · · · · · · · · · · · · · · · · ·				
ASK LOCATION:	TPF/KS	and PPF/WTR			
ASK EQUIPMENT:	124	Cradles	161	Prop Pne	eumatic Console
ASK EQUITIENT.	183	Transporter	127	Data Mg	t Test Set
		Workstand Kit	119	Comm Te	st Set
	191	Prop or Pneumatic	155	Power S	ys Test Set
	- 163	Control Console	148		Cond Unit
	111	ACPS Breakout Box		Umbilic	<del></del>
	117	C/O Access Kit	185		
	118	C/O Cable Kit	180	Enviror	Cool Unit
MANPOWER REQUIRE	MENTS:	PROPULSION TECH		36	M-HRS
		MECHANICAL TECH		- 0	_ M-HRS
		AVIONICS TECH		18	_ M-HRS
		ENGINEERING		18	_ M-HRS
		QUALITY CONTROL		18	_ M-HRS
		SAFETY		0	M-HRS
		OTHER		0	_ M-HRS
		:			

SK OBJECTIVE:	To det	ermine APS status		<u> </u>			-
							-
ASK PURPOSE: _	To ver	ify functional integr	ity and	interfac	e of APS c	omponent	<u>s</u>
and perform lea	k check	(8					_
							_
							_
				<del></del>			
			<del></del>	<del> </del>			
					<del></del>		-
MASK LOCATION:	TPF/K	SC and PPF/WTR					
TASK EQUIPMENT:	124	Cradles	161	Prop Pn	euratic Com	nsole	
	183	Transporter	163	Prop or	Pneumatic	Control	C
	191	Workstand Kit					
	101	ACPS Mod Pres Kit					
f : 	111	ACPS Breakout Box					
	117	C/O Access Kit	<del></del>				
			100	7			
	118	C/O Cable Kit	180		Cool Unit		
MANPOWER REQUIR	EMENTS:	,		50	_ M-HRS		
		MECHANICAL TECH		25	_ M-HRS M-HRS		
		AVIONICS TECH		25	M-HRS		
		ENGINEERING QUALITY CONTROL		25	M-HRS		
		SAFETY		0	M-HRS		
		OTHER		0	M-HRS		
	,	OTHER					

ASK	OBJECTIVE:	To de	termine APS status			
				· · · · · · · · · · · · · · · · · · ·		
ASK	PURPOSE: _	To ve	rify functional integ	rity and	interface	e of APS componer
and	perform lea	k chec	ks, inspect turbo pur	p and si	eaft torque	es
				·		
					<del></del>	· · · · · · · · · · · · · · · · · · ·
					. ·	
	LOCATION:	TPF/I	(SC and PPF/WTR			
	EQUIPMENT:	124	Cradles	161	Prop Pneu	matic Console
		183	Transporter	127	Data Mgt	Test Set
		191	Workstand Kit	119	Comm Test	Set
		163	Prop or Pneumatic Control Console	155	Power Sys	Test Set
		111	ACPS Breakout Box	148	Signal Co	ond Unit
		117	C/O Access Kit	185	Umbilical	
		118	C/O Cable Kit	180	Environ (	<del></del>
MANI	POWER REQUIR			·	84	M-HRS
reur	OMEN NEGOTA	LITENTO	MECHANICAL TECH		0	M-HRS
			AVIONICS TECH		42	M-HRS
			ENGINEERING		42	M-HRS
			QUALITY CONTROL		42	M-HRS
			SAFETY		0	M-HRS
			OTHER		0	M-HRS
•	RFACE REQUI	ncucut	ç.			

TASK OBJECTIVE:	To det	ermine avionics status			
	·				
TASK PURPOSE:	To ver	ify functional integr	ity and	interface	of avionics
	perform	required calibration	•		
Composition		<u> </u>			# · · · · · · · · · · · · · · · · · · ·
		<del></del>		· .	
			156	Prim Bat	t C/O Kit
			121	Comsec E	quipt
TASK LOCATION:	TPF/K	SC and PPF/WTR	159	Prop Uti	lity Comp Test
TASK EQUIPMENT:	127	Cradles	148	Signal C	ond Unit
	183	Transporter	169	Tug Simu	lator
2, 304, 305 07 COMPUTER	191	Workstand Kit	149	Orbiter	Simulator
GRAMS	118	Cable Kit	168	Spacecra	ft Simulator
	119	Comm Test Set	174	Star Tra	cker Sim
	127	Data Mgt Test Set			<del></del>
	155	Power Sys Test Set	180	Environ	Cool Unit
MANPOWER REQUIR	EMENTS:	PROPULSION TECH		0	M-HRS
		MECHANICAL TECH		0	M-HRS
		AVIONICS TECH		327	M-HRS
		ENGINEERING		99.5	_ M-HRS
		QUALITY CONTROL		10	_ M-HRS
		SAFETY		0	_ M-HRS
		OTHER		0	_ M-HRS
INTERFACE REQUI	REMENTS	<b>:</b>			

ASK OBJECTIVE:	To det	ermine Main Propulsion	Status		
· · · · · · · · · · · · · · · · · · ·					
		ify functional integri	ty and	interface	of Main Propulsi
WO I OIM OOM		ges, perform leak chec			
components, veri	fy pur	ges, perform leak thet	LS, and		
·	····				<del></del>
TASK LOCATION:	TPF/K	SC and PPF/WTR			
TASK EQUIPMENT:	124	Cradles	148	Signal C	ond Unit
INDR EQUITION	183	Transporter	185	Umbilica	1 Kit
	1.91	Workstand Kit	161	Prop Pne	eumatic Console
	118	Checkout Cable Kit	117	C/O Acce	ess Kit
	127	Data Mgt Test Set	180		Cooling
	119	Comm Test Set	163	_	Pneumatic Console
	155	Power Sys Test Set			-
				60 ·	M-HRS
MANPOWER REQUIRE	EMEN 13	MECHANICAL TECH		0	_ M-HRS
		AVIONICS TECH		30	_ M-HRS
		ENGINEERING		30	_ M-HRS
		QUALITY CONTROL		30	_ M-HRS
		SAFETY		0	_ M-HRS
		OTHER		0	_ M-HRS
INTERFACE REQUI	REMENT	S:			

		NEW TUG C/O - MAIN PRO termine Main Propulsio				\2.2.7.0
MOK OBJECITVE:	10 44					
					:	
ASK PURPOSE:	To ve	rify functional integr	ity and	interfac	e of Ma	in Propuls
omponents, ver	ify pu	rges, perform leak che	cks and	to calib	rate tra	nsducers
	·					
# · · · · · · · · · · · · · · · · · · ·						
	<u> </u>					
ASK LOCATION:	TPF/K	SC and PPF/WTR				
ASK EQUIPMENT:	124	Cradles	148	Signal	Cond Uni	t
	183	Transporter	185	Umbilic	al Kit	
	191	Workstand Kit	161	Prop Pn	eumatic	Console
	118	Checkout Cable Kit	117	C/O Acc	ess Kit	
	127	Data Mgt Test Set	180	Environ	Cool Un	it
	119	Comm Test Set	163	Prop or Control	Pneumat Console	ic
	155	Power Sys Test Set				
ANPOWER REQUIRE	MENTS	PROPULSION TECH		68	M-HRS	
		MECHANICAL TECH		0	_ M-HRS	
		AVIONICS TECH	·	34	_ M-HRS	
	•	ENGINEERING	· 	34	_ M-HRS	
		QUALITY CONTROL		34	_ M-HRS	
,		SAFETY	<del></del>	0	_ M-HRS	
		OTHER	<del></del>	0	_ M-HRS	
NTERFACE REQUIR	EMENTS	·	·	·		
		in the state of th				

TASK TITLE: PERFORM NEW TUG C/O - MAINTASK OBJECTIVE: To determine Main Propu			22,000 11,000 (1111)
TASK PURPOSE: To verify functional in			
components, verify purges, perform leak	checks and	to calib	brate transducers.
		· · · · · · · · · · · · · · · · · · ·	
TASK LOCATION: TPF/KSC and PPF/WTR			
TASK EQUIPMENT: 124 Cradles	148	Signal	Cond Unit
183 Transporter	185	Umbilic	al Kit
191 Workstand Kit	161	Prop Pn	eumatic Console
118 Checkout Cable K	it 117	C/O Acc	ess Kit
127 Data Mgt Test Se	t 180		Cool Unit
119 Comm Test Set	163		r Pneumatic <u>l Consol</u> e
155 Power Sys Test S	et		·
MANPOWER REQUIREMENTS: PROPULSION TECH		54	M-HRS
MECHANICAL TECH		0	M-HRS
AVIONICS TECH		27 27	M-HRS
ENGINEERING		27	M-HRS M-HRS
QUALITY CONTROL SAFETY	·	0	M-HRS
OTHER		0	M-HRS
INTERFACE REQUIREMENTS:			
enter tien tiedestermines.			

K OBJECTIVE: _	To dete	rmine Main Propulsion			
04 DUDDOCC -	To veri	ify functional integr	ity and	interface	of main propul
SK PURPOSE:	fy nur	ges, perform leak che	cks, and	to cali	orate transducer
omponents, ver					
	mps/vc	C and PPF/WTR			•
ASK LOCATION:			148	Signal C	Cond Unit
ASK EQUIPMENT:	124	Cradles	185	Umbilica	•
	183	Transporter			eumatic Console
-	191	Workstand Kit	161		•
	118	C/O Cable Kit	117	C/O Acc	
	127	Data Mgt Test Set	180		Cool Unit Pneumatic
	119	Comm Test Set	163	Control	Console
	155	Power Sys Test Set	·		
MANPOWER REQUIRE	EMENTS:	PROPULSION TECH		52	M-HRS
		MECHANICAL TECH		0 -	_ M-HRS
		AVIONICS TECH	<del></del>	26	_ M-HRS
	`.	ENGINEERING		26	M-HRS
		QUALITY CONTROL		26	_ M-HRS
		SAFETY		0	_ M-HRS
		OTHER		00	_ M-HRS
	DEMENTS	•			
INTERFACE REQUI	KEMENIS	) i			

K OBJECTIVE: _	To dete	ermine APS status	<del></del>		
			<del></del> .		
SK PURPOSE: _	To ver	ify functional integr	ity and	interfac	e of APS compone
and perform leak	check	s.			
		* .			
	· ·				
TARK LOCATION.	TPF/KS	SC and PPF/WTR	:		
rask location:			161	Prop Fr	neumatic Console
rask equipment:	124	Cradles			
	183	Transporter	127	Data II	gt Test Set
	191	Workstand Kit	119	Comm Te	est Set
	. 163	Prop or Pneumatic Control Console	155	Power	Sys Test Set
		ACPS Breakout Box	148	Signal	Cond Unit
•	111		185		cal Kit
	117	C/O Access Kit			
	118	C/O Cable Kit	180	Enviro	n Cool Unit
MANPOWER REQUIR	EMENTS:	PROPULSION TECH	:	22	M-HRS
1941 Oneit Hadaan		MECHANICAL TECH		0	M-HRS
		AVIONICS TECH		11	M-HRS
		ENGINEERING		11	M-HRS
		QUALITY CONTROL		11	M-HRS
		SAFETY		0	M-HRS
		OTHER	<u></u>	0	M-HRS
INTERFACE REQUI	DCUCN <b>T</b>	S:			

•		termine APS status			
·					
	<del></del>				
SK PURPOSE:	To ve	rify functional integr	ity and	interfac	of APS compone
nd perform lead	chec	<b>.</b>			
	·				
	·		<del></del>		
			·		·
					· · · · · · · · · · · · · · · · · · ·
SK LOCATION:	TPF/K	SC and PPF/WTR			
SK EQUIPMENT:	124	Cradles	161	Prop Pne	umatic Console
	183	Transporter	127	Data Mgt	Test Set
	191	Workstand Kit	119	Comm Tes	
		Prop or Pneumatic			,
	163	Control Console	155	Power Sy	rs Test Set
	111	ACPS Breakout Box	148	Signal (	Cond Unit
	117	C/O Access Kit	185	Umbilics	ıl Kit
	118	C/O Cable Kit	180	Environ	Cool Unit
ANPOWER REQUIRE	MENTS:	PROPULSION TECH	•	36	M-HRS
		MECHANICAL TECH		0	M-HRS
		AVIONICS TECH		18	M-HRS
		ENGINEERING		18	M-HRS
		QUALITY CONTROL		18	M-HRS
		SAFETY		18	M-HRS
		OTHER		0	M-HRS
	EMENTS				-

				<del></del>	
ASK PURPOSE:	To ver	ify functional integr	ity and	interface	e of APS componen
nd perform leak	check	8			
			<del></del>		
TASK LOCATION:	TPF/KS	C and PPF/WTR			
TASK EQUIPMENT:	124	Cradles	161	Prop Pne	eumatic Console
	183	Transporter	127	Data Mgt	Test Set
	191	Workstand Kit	119	Comm Tes	st Set
	,	Prop or Pneumatic	155		vs Test Set
	163	Control Console			
	111	ACPS Breakout Box	148	Signal (	Cond Unit
	117	C/O Access Kit	185	Umbilica	al Kit
	118	C/O Cable Kit	180	Environ	Cool Unit
MANPOWER REQUIRE	EMENTS :	PROPULSION TECH		50	_ M-HRS
		MECHANICAL TECH		0	_ M-HRS
		AVIONICS TECH		25	_ M-HRS
		ENGINEERING		25	_ M-HRS
		QUALITY CONTROL		25 0	_ M-HRS M-HRS
		SAFETY		0	_ M-HRS
		OTHER		<u>~</u>	_ ''-'''\

SK OBJECTIVE:	ro det	ermine APS status			,
SK PURPOSE: _	To ve	rify functional integr	ity and	interface	of APS compone
erform leak che	cks,	inspect turbo pump bea	rings a	nd check s	naft torque.
y's					· · · · · · · · · · · · · · · · · · ·
				* :	
					. *
	<u> </u>			<u> </u>	
TASK LOCATION:	TPF/K	SC and PPF/WTR	. <del> </del>		_
TASK EQUIPMENT:	124	Cradles	161	Prop Pneu	matic Console
	183	Transporter	127	Data Mgt	Test Set
	191	Workstand Kit	119	Comm Test	: Set
	163	Prop or Pneumatic Control Console	155	Power Sys	Test Set
	111	ACPS Breakout Box	148	Signal Co	ond Unit
	117	C/O Access Kit	185	Umbilica:	ı Kit
			180		Cool Unit
	118	C/O Cable Kit			
MANPOWER REQUIRE	MENTS			84 0	M-HRS M-HRS
		MECHANICAL TECH		42	M-HRS
•		AVIONICS TECH ENGINEERING		42	M-HRS
		QUALITY CONTROL		42	M-HRS
		SAFETY		0	M-HRS
	•	OTHER		0	M-HRS
	D#14515			· · · · · · · · · · · · · · · · · · ·	
INTERFACE REQUI	KEMENI	<b>5</b> :			<del></del>

ASK OBJECTIVE:	To det	ermine avionics statu	S		
		and the second s			
					1
ASK PURPOSE: _	To ver	rify functional integr	ity and	interrac	e or avionics
components and I	perform	n required calibration	1		
			159	PU Com	onent Test Set
		s.	156	Prim Ba	tt C/O Kit
TACK LOCATION.	TPF/F	CSC and PPF/WTR	121	Comsec	Equipt
TASK LOCATION:			148	Signal	Cond Unit
TASK EQUIPMENT:	124	Cradles			
302, 304, 305	183	Transporter	169	Tug Sin	nulator
& 307 COMPUTER	191	Workstand Kit	148	Orbite	r Simulator
PROGRAMS	118	Cable Kit	168	Spacec	raft Simulator
		Corm Test Set	174	Star T	racker Sim
	119				
	127	Data Mgt Test Set			
	155	Power Sys Test Set	180	Fnviro	n Cool Unit
MANPOWER REQUIR	EMENTS	: PROPULSION TECH		0	M-HRS
		MECHANICAL TECH		0	M-HRS
		AVIONICS TECH		48.5	M-HRS
		ENGINEERING		69	M-HRS
		QUALITY CONTROL		10	M-HRS
		SAFETY		0	M-HRS
		OTHER		0	M-HRS

TASK OBJECTIVE: To prov	The lines upuate	72 541.543			Conp.	
unscheduled M&R tasks						
	·	· · · · · · · · · · · · · · · · · · ·	<del> </del>	·		<del> </del>
ASK PURPOSE: Incorpo	orates unscheduled	M&R requirem	ents res	ulting	g fro	m post
flight/receiving inspec	ction and post flig	ght, post sto	rage, am	nd new	tug	checkou
		<del> </del>				
- <u></u>						
						· · · · · · · · · · · · · · · · · · ·
TASK LOCATION: TPF/KS	C and PPF/WTR					
				, <u>, , , , , , , , , , , , , , , , , , </u>		
TASK EQUIPMENT: 127	Data Mgt Test Set	<del>,</del>				
egi eng	·					
				<del></del>		
		· ·				
· · · · · · · · · · · · · · · · · · ·						
				<del></del>		
MANPOWER REQUIREMENTS:	PROPULSION TECH	0	•	M-HRS		
	MECHANICAL TECH	0		M-HRS		
	AVIONICS TECH	0		M-HRS		•
	ENGINEERING _	14		M-HRS		
	QUALITY CONTROL	<u> </u>		M-HRS		
	SAFETY	<u> 4</u>		M-HRS		
	OTHER _	0	<del></del>	M-HRS		
	·					

ASK OBJECTIVE: To	corre	ct structure/	nechanical	subsystem	discrepanc	ies
*			^	-		
				·		<u></u>
		<u> </u>		<del> </del>		
		k is primaril				
&R tasks required	d to ma	intain/restor	e the Spac	e Tug to s	atisfactory	condition.
he magnitude of	this te	sk will vary	with the c	onfigurati	on and each	individual
nission.				· · · · · · · · · · · · · · · · · · ·	•	·
				*		
			<del></del>			
				<u> </u>		,
					·	
TASK LOCATION: T	PF/KSC	and PPF/WTR				
TASK EQUIPMENT:	124 C	radles				
		ransporter		,		
•		1			· · · · · · · · · · · · · · · · · · ·	
•	191 W	orkstand Kit				
					<del>,</del>	
			·			
MANPOWER REQUIRED	MENTS.	PROPULSION TE	CH	0	M-HRS	
MITOREN NEGOTNE	<u></u>	MECHANICAL TE		17	M-HRS	
	•	AVIONICS TECH		0	M-HRS	
		ENGINEERING		0	M-HRS	
		QUALITY CONTR	OL	0	M-HRS	
		SAFETY		0	M-HRS	
		OTHER		0	M-HRS	
INTERFACE REQUIRE	EMENTS:					

SK OBJECTIVE: To						
					<u> </u>	
ASK PURPOSE: _Thi	s ta	sk is primarily co	ncerned w	ith the	e performan	ce of unsche
&R tasks required	to m	aintain/restore th	e Space T	ug to	an operable	condition.
The magnitude of th						
					•	
nissions.						
<del></del>				<del> </del>		
			· · · · · · · · · · · · · · · · · · ·			
TASK LOCATION: TP	r/KSC	and PPF/WTR				
rask equipment: 1	24	Cradles		160	Prop Comp	Repair Kit
1	83	Transporter				
1	91	Workstand Kit			·	
	30	Engine Actuation	Fixture			
	31	Engine Align Kit			· · · · · · · · · · · · · · · · · · ·	
1	32	Engine Handling K		· · · · · · · · ·		
<u>1</u>	33	Engine Position F	ixture		<del></del>	
MANPOWER REQUIREMENT	NTS:	PROPULSION TECH		14	M-HRS	
		MECHANICAL TECH		0	M-HRS	
		AVIONICS TECH		0	M-HRS	
		ENGINEERING	<del>-</del>	0	M-HRS	
		QUALITY CONTROL		0	M-HRS	
		SAFETY			M-HRS	
		OTHER	<del></del>	0	M-HRS	
INTERFACE REQUIREM	ENTS	•	<del> </del>			

ASK OBJECTIVE.		ect avionics subsy			
			<u></u>		
TASK PURPOSE:	This ta	sk is primarily co	ncerned wit	h the	performance of
unscheduled M&R	tasks r	equired to maintai	n/restore t	he Sp	ace Tug to an operab
			the state of the s		configuration and
					•
each individual	mission	•			
			; 		
TASK LOCATION:	TPF/KS	and PPF/WTR			
	124	Cradles		143	Guid & Nav System C
TASK EQUIPMENT:					
304, 305 & 307	183	Transporter			
COMPUTER	191	Workstand Kit			
PROGRAMS	115	Battery Handling	Kit	159	PU Test Set
				164	Battery C/O Kit
				174	Star Tracker Test S
	142	Guid & Nav Test	Set.		
				0	M-HRS
MANPOWER REQUIR	EMENTS:	PROPULSION TECH MECHANICAL TECH		0	M-HRS
		AVIONICS TECH		32	M-HRS
		ENGINEERING		0	M-HRS
		QUALITY CONTROL		0	M-HRS
		SAFETY		0	M-HRS
		OTHER		0	M-HRS
INTERFACE REQUI	DEMENTS	•			

rea.	lear area around the			
ASK PURPOSE: To d	isconnect and remove	GSE, required	during M&R to	a positio
	ructed movement of th	ne Tug.		
			N. Say	
				·
				, i
				• .
TASK LOCATION: TPF	/KSC and PPF/WTR			<u> </u>
TASK EQUIPMENT: 12	4 Cradles			•
18	3 Transporter			
				•
19	Ol Workstand Kit			
MANPOWER REQUIREMEN	ITS: PROPULSION TECH	0	M-HRS	
PANTONER REQUIREMENT	MECHANICAL TECH		M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	0	M-HRS	
	QUALITY CONTROL		M-HRS	
	SAFETY	0	M-HRS M-HRS	
	OTHER		11-11100	

SK TITLE: RECEIVE FS	ically enter FSE in	nto the M&R cycles	. This ta	sk and
ubsequent tasks conside	er (1) New FSE, (2)	FSE from post lan	ding opera	tions
nd (3) FSE from storage	•			
		time tage and t	renefer FS	E to e
ASK PURPOSE: <u>To inverted</u>	ntory FSE, prepare	POULTING CARS and V	A. 58.44.18.4. Sec	
ropriate work area.			<u> </u>	<del> </del>
				,
ASK LOCATION: TPF/KSC	and PPF/WTR			
ASK EQUIPMENT: 134	Eduthe Ami	_ <del></del>	<del></del>	
			<del></del>	
<del></del>				
<u> </u>			<del></del>	
-	·			
ANDOUED DECUT DENENTS .	PROPULSION TECH	0	M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH	3	M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	0	_ M-HRS	
	QUALITY CONTROL _	0	M-HRS	
	SAFETY	0	_ M-HRS	
	OTHER	3	M-HRS	
	_			
INTERFACE REQUIREMENTS				

SK OBJECTIVE: Pe	rform	those tasks	required to	facilitate	inspection	<u> </u>
· · · · · · · · · · · · · · · · · · ·				· 	·	
			1 - E			
			A Ohan	clean FSE ex	ternal surfa	ce.
				CIGAN 100 CX		
osition/connect	GSE and	perform se	lf check.			
						<del></del>
ASK LOCATION:	PF/KSC	and PPF (W	TR)	·	·	
•	3.01:	Cradles				
ASK EQUIPMENT:	124	•			•	
	183	Transporter	• 			
	191	Workstand N	Cit			
•	181	Tilt Table	Handling Ki	t		
	, '					
MANPOWER REQUIRE	MENTS:	PROPULSION	TECH	0	M-HRS	
		MECHANI CAL		16	M-HRS	
	•	AVIONICS T		0	M-HRS	
		ENGINEERIN		0	M-HRS	
		QUALITY CO	NIKUL	0	M-HRS	
		SAFETY	<del></del>	0	M-HRS	
		OTHER				
	REMENTS	_				

	trumentation is no			<u> </u>
To ident	ify unscheduled M&	R requirements	not previously	/ identi
SK PURPOSE: 10 Ident		v .		
				<del></del>
				······································
		<u> </u>	• .	
				:
			-	
				<del> </del>
ASK LOCATION: TPF/KSC	and PPF/WTR			
ASK EQUIPMENT:	* * * * * * * * * * * * * * * * * * *			:
Mak Edostilism.				¥
		and the second second		
·			· · · · · · · · · · · · · · · · · · ·	
MANPOWER REQUIREMENTS:	PROPULSION TECH	4	M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH	11.5	M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH	11.5 12	M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING	11.5 12 0	M-HRS M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING QUALITY CONTROL	11.5 12 0 16	M-HRS M-HRS M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING	11.5 12 0	M-HRS M-HRS M-HRS	

TASK TITLE: PREPARE/U	PDATE M&R SCHEDULE	(1.1.18)		· · · · · · · · · · · · · · · · · · ·
TASK OBJECTIVE: To prov	ide final update o	f M&R schedule pr	or to acco	mplishing
unscheduled M&R tasks.				
		·		
		• .		
TASK PURPOSE: Incorpo	rates unscheduled	M&R requirements	resulting i	rom Post
Flight/Receiving Inspec	and the second s			
			•	
		<u>.</u>	<del></del>	
	-			
TASK LOCATION: TPF/KSC	and PPF/WTR			····
TASK EQUIPMENT: 127	Data Mgt Test Set			
-	C/O Cable Kit (Par	rtial)		
			·	
		·		
MANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS	
Isali Gush hedanahama	MECHANICAL TECH	0	M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	8.5	M-HRS	
	QUALITY CONTROL	1.5	M-HRS	
	SAFETY	1.5	M-HRS	
	OTHER -	0	M-HRS	
INTERFACE REQUIREMENTS			<del> </del>	

SK TITLE: PERF		1 - a	4 2
SK OBJECTIVE: To	correct FSE discrepance	1es.	
			3
	nis task is primarily co	reerned with the u	nscheduled M&R
sks required to	maintain/restore the Tu	g FSE to a satisfa	etory condition,
owever, there are	e some scheduled M&R tas	ks such as cleanin	g fluid umbilicals.
			· .
ASK LOCATION: T	PF and LOX Clean Facility	ty/KSC and PPF and	LOX Clean Facility/
ASK EQUIPMENT:	160 Prop Component Re	pair Kit	
	181 Tilt Table Fixtur		
	101 1110 10020 1		
			`
MANDOLIED DEGITOEN	MENTS · PROPULSION TECH	32	
MANPOWER REQUIREM	MENTS: PROPULSION TECH MECHANICAL TECH	32 16	M-HRS M-HRS
MANPOWER REQUIREN			·
MANPOWER REQUIREN	MECHANICAL TECH	16	M-HRS M-HRS M-HRS
MANPOWER REQUIREM	MECHANICAL TECH AVIONICS TECH	16 16	M-HRS M-HRS M-HRS M-HRS M-HRS
MANPOWER REQUIREM	MECHANICAL TECH AVIONICS TECH ENGINEERING	16 16 0 0	M-HRS M-HRS M-HRS M-HRS M-HRS
MANPOWER REQUIRE	MECHANICAL TECH AVIONICS TECH ENGINEERING QUALITY CONTROL	16 16 0	M-HRS M-HRS M-HRS M-HRS M-HRS

		the Tug in a cond	ition wh	ereby it	can be stored w	16
nimum subsystem d	legrad	lation.	· · · · · · · · · · · · · · · · · · ·			
	. 1					-
SK PURPOSE: Thi	is tas	sk includes battery	removal	l, instal	lation or dessic	an
		ig, installing prot				
caage, creaming			1.6			
ASK LOCATION: TP	F/KSC	and PPF/WTR				
	124	Cradles	180	Environ	Control Unit	
			115		Pandling Kit	
	183	Transporter		SALLETY	THE THE PARTY OF	
·	191	Workstand Kit			<u> </u>	
-	123	Cover-Tug				
	120	Component Protecti	ve Cove	rs		
· ·	175	Static Dessicant ?	it			
		~.				
- MANPOWER REQUIREME	· PTN:	PROPULSION TECH		6	M-HRS	
- MALONEK WEGOTWEN		MECHANICAL TECH		24	M-HRS	
		AVIONICS TECH		2	M-HRS	
		ENGINEERING		0	M-HRS	
		QUALITY CONTROL		0	M-HRS	
		SAFETY _		0	M-HRS	
		OTHER _		0	M-HRS	

		the Tug in a tran	<del>-</del>	:		
<u>.</u>				<del>-,</del>		
	<u> </u>			* 2		:
ASK PURPOSE:	his tas	sk includes closin	g and secu	ring acc	ess panels, a	nd
hooking up to a	. prime	mover				
					•	
			· · · · · · · · · · · · · · · · · · ·			
TASK LOCATION:						
·	124	Cradles			• *,	
TASK EQUIPMENT:						
	183	Transporter				
	191	Workstand Kit				
•	182	Tractor - Transpo	rter			
		•		, W		
` .	. ———					
					<del></del>	
MANPOWER REQUIRE	MENTS:	PROPULSION TECH		0	M-HRS	
		MECHANICAL TECH		7	M-HRS	
		AVIONICS TECH		0	M-HRS	
e e e e e e e e e e e e e e e e e e e	•	ENGINEERING	·	0	M-HRS M-HRS	
		QUALITY CONTROL SAFETY		0	M-RKS M-HRS	
·.		OTHER	. <u> </u>	1	M-HRS	
INTERFACE REQUIS						

ASK TITLE: TRANSFE	and the The in a design	ted storage a	rea.	
ISK OBJECTIVE: To 10	cate the Tug in a designa	ted 3001 ange a		
ACH DUDDOCE TO TO	ove Tug from TPF/PPF to st	orage area.		
ASK PURPOSE: To mo	77C 14g 1102 517/51			
		· · · · · · · · · · · · · · · · · · ·		
		······································		
		· ·		
		·		
			` A / 1.75TD	
TASK LOCATION: TPF	to Storage Area/KSC and Pi	PF to Storage	Area/win	
		PF to Storage	Area/win	
TASK EQUIPMENT: 121	+ Cradles	PF to Storage	Area, wir	
TASK EQUIPMENT: 121	Cradles Transporter	PF to Storage	Area, wir	· · · · · · · · · · · · · · · · · · ·
TASK EQUIPMENT: 121	cradles Transporter Cover-Tug		Area, win	
TASK EQUIPMENT: 121	Cradles Transporter Cover-Tug		Area, wir	· · · · · · · · · · · · · · · · · · ·
TASK EQUIPMENT: 121 183	Cradles Transporter Cover-Tug Component Protective C		Area, wir	· · · · · · · · · · · · · · · · · · ·
TASK EQUIPMENT: 121 183 123	Cradles Transporter Cover-Tug Component Protective C		Area, wir	· · · · · · · · · · · · · · · · · · ·
183 123 120 120 120 120 120 120 120 120 120 120	Cradles Transporter Cover-Tug Component Protective C		Area, wir	
183 123 126 183	Cradles Transporter Cover-Tug Component Protective	overs		
183 123 126 183	Cradles Transporter Cover-Tug Component Protective	overs 0	M-HRS	
183 123 126 183	Cradles Transporter Cover-Tug Component Protective	overs 0		
183 123 126 183	Cradles Transporter Cover-Tug Component Protective	overs 0	M-HRS	
183 123 126 183	Cradles Transporter Cover-Tug Component Protective	O 4 0	M-HRS M-HRS M-HRS	
183 123 126 183	Cradles Transporter Cover-Tug Component Protective	O 4 0 0	M-HRS M-HRS M-HRS M-HRS	
TASK EQUIPMENT: 121 183 123	Cradles Transporter Cover-Tug Component Protective	0 4 0 0	M-HRS M-HRS M-HRS M-HRS M-HRS	

WER OBSECTIAE:	10 11111111	ize subsystem degr			
		orm inspection, ser	mining and other	r preventive	e maintens
ASK PURPOSE: _	To perfo	orm inspection, ser	AIGINE and Other	i preventivo	
asks, as requir	ed.			<del></del>	
		-		•	
				. ,	
				· · · · · · · · · · · · · · · · · · ·	
TASK LOCATION:	Designa	ted Storage Area a	t KSC and WTR		·
TASK EQUIPMENT:	180	Environ Control U	nit	·	
INSK EQUIFICATI	<del></del>				
	124	Cradles			
·	183	Transporter			
	123	Cover-Tug	<u> </u>		
	120	Component Protect	ive Covers		
			,		
MANPOWER REQUIR	EMENTS:	PROPULSION TECH	4	M-HRS	
IMILONEIL INEGOTI		MECHANICAL TECH	14	M-HRS	
		AVIONICS TECH	<b>1</b> 4 ·	M-HRS	
		ENGINEERING	0	M-HRS	
		QUALITY CONTROL	4	M-HRS	
	•	SAFETY	0	M-HRS	
		OTHER	0	M-HRS	

K OBJECTIVE: Determi	ne Tug physical condition	on and prace	145 111 4 11	
ndition.				
				· ·
				:
Tagast	Tug for general condit	ion, identify	subsystem	discrepand
	- · · · · · · · · · · · · · · · · · · ·			
d prepare for transpo	rt.	<u>, i</u>		<del></del>
ASK LCCATION: Design	ated Storage Area at KSC	and WTR		
ASK EQUIPMENT: 124	Cradles			
183	Transporter	,		
	Cover-Tug			
123				
120	Component Protective C	overs		
			<u> </u>	
			<del></del>	
MANPOWER REQUIREMENTS	PROPULSION TECH	Ļ	M-HRS	•.
MILANCE VERATURIENTS	MECHANICAL TECH	4	M-HRS	
	AVIONICS TECH	4	M-HRS	
	ENGINEERING	0	M-HRS	
	QUALITY CONTROL	4	M-HRS	
	SAFETY	0	M-HRS	
	OTHER	0	M-HRS	
INTERFACE REQUIREMENT	ç.			

	e the Tug at the TP			
ASK PURPOSE: To move	Tug to TPF/PPF from	storage area.		<u> </u>
			•	
			,	
		<u> </u>	<del> </del>	
				<del></del>
	·	·		
				· ·
MASK LOCATION: Storage	Area to TPF/KSC and	Storage Area to	o PPF/WIR	<u> </u>
TASK EQUIPMENT: 124	Cradles			
	Pransporter	·		
·	Cover-Tug			
120	Component Protective	e Covers		
	Component Protective Cractor - Transporte			
182 1		0	M-HRS	
182 1	PROPULSION TECH	0 2	M-HRS	
182 1	PROPULSION TECH	0 2 0	M-HRS	
182 1	PROPULSION TECH	0 2 0	M-HRS M-HRS M-HRS	
182 1	PROPULSION TECH	0 2 0 0	M-HRS M-HRS M-HRS M-HRS	
182 1	PROPULSION TECH	0 2 0 0 0	M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS	
	PROPULSION TECH	0 2 0 0	M-HRS M-HRS M-HRS M-HRS	

SK OBJECTIVE: To locat	e the rug at the Freiat	Men area		
SK PURPOSE: To move	Tug from M&R area to P	relaunch area	<u> </u>	
ጥቦኛ ተለ	VAB/KSC and PPF to VAB	/WTR		
ASK LOCATION: TPF to	They have the			
ASK EQUIPMENT: 124	Cradles			
183	Transporter			
1'82	Tractor - Transporter		-	
<del></del>				
			<del></del>	
				,
MANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS	
	MECHANICAL TECH	4	M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	00	M-HRS	
	QUALITY CONTROL	0	M-HRS	
	SAFETY	0	M-HRS	
	OTHER	4	M-HRS	
• • • • • • • • • • • • • • • • • • •				

will now function	satisf	actorily and that the	Tug 1s	ready 10	or transier to pr
launch area.					
					- A subsystem dis
TASK PURPOSE: To	verif	y that fault detection	n and is	solation	or subsystem dra
		, M&R tasks were perfo		rectly,	and that perior
of M&R tasks have	clear	ed subsystem discrepan	cies.		
				<del></del>	
TASK LOCATION:	PF/KSC	and PPF/WTR		· 	
TASK EQUIPMENT:	124	Cradles	156	Prim B	att C/O Kit
Signal Cond Unit	183	Transporter	169	Tug Si	mulator
_	191	Workstand Kit			
Umbilical Kit	118	C/O Cable Kit	168	Spaced	raft Simulator
Prop Pneum Console	127	Data Mgt Test Set	174	Star T	racker Test Set
Environ Cooling	119	Comm Test Set		,	
Prop Util Test Set			111	APS Br	reakout Control B
, 305 & 307 PUTER PROGRAMS	155	Power Sys Test Set			· ·
MANPOWER REQUIRE	MENTS:			2	M-HRS M-HRS
		MECHANICAL TECH		± 1	M-HRS
		AVIONICS TECH		0	M-HRS
		ENGINEERING		4	M-HRS
		QUALITY CONTROL SAFETY		0	M-HRS
		OTHER		0	M-HRS
		UTIEK			

unction satisfacto	orily and that the Tug	g is ready for to	eansfer to the pr	elaun
rea.				
ASK PURPOSE: To	verify that performan	nce of FSE M&R to	asks have correct	ed
reviously identif	led discrepancies.			<u></u>
			•	
			•	
ASK LOCATION: TP	F/KSC and PPF/WTR		•	
ASK EQUIPMENT:		181 Til	t Table Handling	Kit
	18 C/O Cable Kit	_	ilical Kit	
	27 Data Mgt Test Se		11.000	
-	19 Comm Test Set			
. <del>-</del>		-4	· · · · · · · · · · · · · · · · · · ·	
_	.55 Power Sys Test S			
	48 Signal Cond Unit	······································	<u> </u>	
<u>1</u>	49 Orbiter Simulato			
MANPOWER REQUIREME			M-HRS	
	MECHANICAL TECH		M-HRS	
	AVIONICS TECH	2	M-HRS	
	ENGINEERING	8	M-HRS	
	QUALITY CONTROL	0	M-HRS	
	SAFETY	0	M-HRS	
•	OTHER		M-HRS	
NTERFACE REQUIREM	ENTS:	**************************************		

ASK UDUECITIE:	flight configuration			
transport to Orbite	MCF where it will	be installed in	the flight	t
vehicle.		<u> </u>		
			· · · · · · · · · · · · · · · · · · ·	
ASK PURPOSE: To assem	ble the total compl	ement of FSE requ	ired for	the
1017 1 0111 00	will receive, chec			
a van for transport				
a van for transport	to the orbital			
				<del></del>
			<u></u>	
ASK LOCATION: TPF/KSC	and PPF/WTR			
	Transport Van			
MSK EQUIPMENT:				
	Dollies		· · · · · · · · · · · · · · · · · · ·	
	Low Boy			
<del></del>				
	222211 22211 27211		M-HRS	
MANPOWER REQUIREMENTS:	PROPULSION TECH		M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	0	M-HRS	* .
	QUALITY CONTROL	2	M-HRS	
	SAFETY	2	M-HRS	
	OTHER	11	M-HRS	
INTERFACE REQUIREMENTS				

550-60

ASK OBJECTIVE: R	eceipt of the Tug vehicle	from the Maint	enance and	
lefurbishment ope	rations.			
				<del></del>
MON LOULOGE:	his task initiates the Pr			<u> </u>
vehicle, and incl	udes preparatory work for	r flight config	uration.	
·				
ASK LOCATION:	TPF/KSC and PPF/WTR			الكسين المساور
TASK EQUIPMENT:	191 Side Workstands			
	183 Transporter			
	124 Cradles			
	,			
. '	·			
MANPOWER REQUIREM	ENTS: PROPULSION TECH _	0	M-HRS	
	MECHANICAL TECH	0	M-HRS	
	AVIONICS TECH _	0	M-HRS	
	ENGINEERING	0	M-HRS M-HRS	
	QUALITY CONTROL _	0	M-HRS	
	SAFETY OTHER	5.5	M-HRS	
	VINER			
INTERFACE REQUIRE	MENTS:			

-Sh D-61

ASK OBJECTIVE: To prep	are the Tug vehicle	for transfer to t	he DOD Paylo	oad ———
Processing Facility at	KSC for DOD spacecro	aft work prior to	launch.	
To ones	psulate the Tug in	a protective cover	to insure	vehic
ASK FOR OSE.			<u> </u>	
100,000 class cleanline	ess.			
			<u></u>	
· .				
TASK LOCATION: TPF/KS	c			
TASK EQUIPMENT: 123 T	ug Covers		<del></del>	
Cover	Bar			
124 Cradle	es .			
183 Trans	oorter			
191 Workst				
191 WOLKS	Alla KIU		· ·	
MANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS	
	MECHANICAL TECH	0	M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	0	M-HRS	
•	QUALITY CONTROL	0	M-HRS	
	SAFETY	13	_ M-HRS	
	OTHER	7.3	_ M-HRS	
INTERFACE REQUIREMENTS			•	

K TITLE: TRANSFER TU	de the Tug vehicle at	the PPF for	preflight	spacecra
rk required for a DOD				
			<del></del>	
	sfer the Tug vehicle fr	om the TPF	to the PPF	at KSC.
SK PURPOSE: To trans	sier the lug venicle in	- CAL - CAL		
ASK LOCATION: TPF-to-	PPF/KSC			
<del></del>				
124 Cradle	5			
123 Cover-	Tug			
182 Transp	orter Tractor			
			M-HRS	
MANPOWER REQUIREMENTS:	PROPULSION TECH		M-HRS	
•	MECHANICAL TECH	0	M-HRS	
	AVIONICS TECH ENGINEERING	0	M-HRS	
	QUALITY CONTROL	2	M-HRS	
	SAFETY	0	M-HRS	
•	OTHER	9	M-HRS	
	~ · · · · · · · · · · · · · · · · · · ·			

TASK IIILE:		PAYLOAD TO SEE		<del> </del>		
INON ODDEDITION		of the Tug to			t Facility	for
loading of the St	orable	Attitude Contro	l Propulsion	System	:	
	,				· · ·	
				-d +o +bi	e fecility	to all
TASK PURPOSE:	The Tug	and Spacecraft	are transier	ed co cm	S TacTIIO	
loading of the A	CPS.					
TASK LOCATION: 1	PT -to-	-SPF/KSC and WTR	·.			
TASK EQUIPMENT:	183 <b>ጥ</b>	ransporter			,	
					•	
182	Tracto	r- Transporter			· · · · · · · · · · · · · · · · · · ·	
				· .		
123/122	Covers				<del></del>	
••	·- \			· · · · · · · · · · · · · · · · · · ·		
194	(Secur	ity Vehicle)	· .	·.		
194	1 Decax			-		
			•		M-HRS	
MANPOWER REQUIRE	MENTS:	PROPULSION TECH MECHANICAL TECH		1	M-HRS	
		AVIONICS TECH		0	M-HRS	
		ENGINEERING		2	M-HRS	
		QUALITY CONTROL		0	M-HRS	
		SAFETY		0	M-HRS	٠
		OTHER	9	/17	M-HRS	

		ete the prelaunch ser		·
titude control	proputs	IOI Systems		
				tested at the
		able ACPS is purged,		k tested at the
F before trans	fer to t	he MCF for Orbiter i	ntegration.	
	·····			
			185 Umbilical	Kit.
SK LOCATION:	SPF/KSC	and WTR	- <del> </del>	
ASK EQUIPMENT:	112 A	S Loading Access Kit	183 Transport	er
			182 Tractor	
-			123 Covers	
	SCAPE S	Suits (2)	109 Portable	Cleanliness Tent
120		npling Equipment	192 (Security	Vehicle)
139				
		tic Console		
113	Propel	lant Servicer		
ANPOWER REQUIRE	EMENTS:	PROPULSION TECH	<u>40</u> 8	_ M-HRS M-HRS
•		MECHANICAL TECH	10	_ M-HRS
		AVIONICS TECH	34	M-HRS
		ENGINEERING	18	M-HRS
		QUALITY CONTROL SAFETY	17	M-HRS
		OTHER	2/21	M-HRS
	REMENTS			

		PELLANT SERVICING			
ASK OBJECTIVE:	To comple	te the prelaunch	servicing of	tne st	orable monopropellan
attitude control	propulsi	on system.	·	<del>*</del>	
			· .		
TASK PURPOSE:	The store	able ACPS is purge	d, loaded, a	nd leal	tested at the
launch med with		inside the payload			
		3 1			
umbilicals.					
				·	
				<del> </del>	
		·			
TASK LOCATION:	Launch P	ad/KSC and WTR			
TASK EQUIPMENT:	112 AF	S Loading Access	Kit 185	Launch	Umb Sys
118	Cable Ki	t	143_	Signal	Conditioning Unit
	*-		155	Power	Svs Test Set
	GOADE C	nites (2)	176		s Monitor Consoles
	_		2	<del></del>	·
139		oling Equipment	127	DMST/S	
162	Pneumat	ic Console	128	Teleme	etry Ground Station
113	Propelle	ant Servicer	163	Prop	or Pneu. Cont. Conso
MANPOWER REQUIF	REMENTS:	PROPULSION TECH	36	5	M-HRS
		MECHANICAL TECH _		5	M-HRS
		AVIONICS TECH _	2:		M-HRS
		ENGINEERING	7		M-HRS
	•	_	^	")	M_UDC
	•	QUALITY CONTROL _	2		M-HRS M-HRS
	•	_	2		M-HRS M-HRS M-HRS

	o complete the prelaunch se	ervicing of the st	orable bi-
	de control propulsion syste		
ASK PURPOSE:	he storable ACPS is purged	, loaded, and leak	tested at the
	er to the MCF for Orbiter	integration.	
	,		
ASK LOCATION: _S	SPF/KSC and WTR	185 Umbilical	Kit
TASK EQUIPMENT:	112 APS Loading Access Kit	t 183 Transporte	r
Non Edamination		182 Tractor	
•	en en en en en en en en en en en en en e	122/123 Covers	3
•	SACPE Suits (2)	109 Portable (	Cleanliness Tent
•	Gas Sampling Equipment	192 (Security	Vehicle)
	Pneumatic Console		
101	Propellant Servicers (2)		
		88	M-HRS
MANPOWER REQUIREM		10	M-HRS
	MECHANICAL TECH AVIONICS TECH	14	M-HRS
	ENGINEERING	46	M-HRS
	QUALITY CONTROL	23	M-HRS
	SAFETY	23	M-HRS
	OTHER	2/38	M-HRS
	EMENTO.		
INTERFACE REQUIRE	EMEN13:		

U3V 19100	RABLE PROPELLANT SERVICING (2		
ASK OBJECTIVE:	To complete the prelaunch ser	rvicing of the s	torable bipropellan
attitude control	propulsion system.		·
	The storable ACPS is purged,	loaded, and le	ak tested at the
		the state of the s	
launch pad, with	the Tug inside the payload	bay, using the	1-20 Service
umbilicals.			
*			
			·
TASK LOCATION:	Launch Pad/KSC and WTR		
rask equipment:	112 APS Loading Access Kit	146 Launch	Umb Sys
118	Cable Kit	148 Signal	Conditioning Unit
	•	155 Power	Svs Test Set
	SCAPE Suits (2)	176 Subsys	Monitor Consoles
120	Gas Sampling Equipment	127 DMST/S	
139		`	try Ground Station
162	Pneumatic Console		
113	Propellant Servicers (2)	163 Prop o	or Pneu_Cont. Consol
MANPOWER REQUIRE	MENTS: PROPULSION TECH	54	_ M-HRS
	MECHANICAL TECH	54	_ M-HRS M-HRS
	AVIONICS TECH	106	M-HRS
	ENGINEERING	32	M-HRS
	WINI I I A CONTROL		
	QUALITY CONTROL SAFETY	20	M-HRS
	SAFETY CONTROL	20 26	_ M-HRS _ M-HRS
INTERFACE REQUI	SAFETY		<del>-</del>

SK OBJECTIVE: To p	repare the Tug and work	area for instar	.100200 01 0.	
quipment for a retr	ieval mission.			
	i i			
Ma s	ssemble the Tug and spa	cecraft retrieve	al unique eq	uipmer
	a for prelaunch integrat			
ogether in one area	for prelaunen integrat	2011 110211 010		
				<u></u>
ASK LOCATION: TPF	or PPF/KSC and PPF/WTR		<del></del>	
ASK EQUIPMENT: 183	Transporter			
134 Var	1			
191 Wo	rk Stands			
124 <u>Cr</u>	adles		· · · · · · · · · · · · · · · · · · ·	
182 <u>Tr</u>	actor - Transporter			
•				
AANPOWER REQUIREMEN	TS: PROPULSION TECH	. 0	M-HRS	
MAPONER REQUIREMENT	MECHANICAL TECH	1	M-HRS	
	AVIONICS TECH	1	M-HRS	
•	ENGINEERING	0	M-HRS	
	QUALITY CONTROL	11	M-HRS	
	SAFETY	0	M-HRS	
	OTHER	6/6.5	M-HRS	
INTERFACE REQUIREME	NTS:			

MUN 1815	ALL SPACECRAFT EQUIPMENT			<del> </del>
SK OBJECTIVE: To	install spacecraft uniqu	e equipment	for a DOD retr	rieval
nission.		·		
	o complete the spacecraft	* * *	nstallation on	n the Tu
vehicle for DOD sp	acecraft retrieval mission	ons.		
		•		
				·
TASK LOCATION: PI	PF/KSC and WTR			
TASK EQUIPMENT: 1	91 Work Stands and Platf	'orms		
183 T	ransporter			
150 P	ayload Adapter Handling Eq	quipment		
124 0	radles		· · · · · ·	
_	ractor - Transporter		·	
. —		<u> </u>		
184 7	lug Support Kit Vertical			
	Sa		<u></u>	
MANPOWER REQUIREME		0	M-HRS	
	MECHANICAL TECH	<u>1</u> 4	M-HRS M-HRS	
	AVIONICS TECH ENGINEERING	0	M-HRS	
	QUALITY CONTROL	2	M-HRS	
	SAFETY CONTROL	0	M-HRS	
	OTHER	3	M-HRS	
				,

52 0-70

SK OBJECTIVE: To insta	ACECRAFT EQUIPMENT (2.	equipment for	a NASA spacecraft
etrieval mission.			
ASK PURPOSE: _To comp	late the engageraft eq	uipment inst	allation on the Tug
wehicle for NASA spacec	raft retrieval mission	5.	
·		· 	
·			
			·
TASK LOCATION: TPF/KSC	and PPF/WIR		
rask equipment: 191 W	ork Stands and Platfor	ms	
183 Transp	orter		
150 Payloa	d Adapter Handling Equi	nment.	
124 Cradle			
TEV CIGULE			
	·		<del></del>
	PRODUCTON TECH		M-HRS
MANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS
	AVIONICS TECH	2	M-HRS
	ENGINEERING	0	M-HRS
	QUALITY CONTROL	2	M-HRS
	SAFETY	0	M-HRS
			M-HRS
	OTHER	Ц	Mauro

W3V 111FF	ERIFY TUG-TO-SPACECRAFT EQU		
ASK OBJECTIVE:	To establish flight reading	ness of spacecraft	interfaces for a
retireval missio	on.		
ASK PURPOSE: _	To test and verify the sp	acecraft equipment	interfaces
operability.			
		.,	
			·
	· · · · · · · · · · · · · · · · · · ·		
	TOTAL TOTAL TOTAL	XND	
TASK LOCATION:	PPF and TPF/KSC and PPF/V	'IR	
TASK EQUIPMENT:	124 Cradles	155 Po	wer Sys Test Set
	183 Transporter	148 Si	gnal Cond Unit
	191 Work Stands and Pla	† forms	
•			<del></del>
	168 Spacecraft Simulato		
	118 C/O Cable Kit	185 Um	bilical Kit
	127 Data Ngt Test Set	149 Or	biter Simulator
	119 Comm Test Set	304 305 & 3	07 COMPUTER PROGR
٠,			
MANPOWER REQUIR		<b>0</b>	_ M-HRS M-HRS
	MECHANICAL TECH _ AVIONICS TECH	15	M-HRS
	ENGINEERING	8.5	M-HRS
	QUALITY CONTROL _	0	M-HRS
	SAFETY	0	M-HRS
	OTHER	0	M-HRS
	¥ · · · <del>_</del> _		

ASK OBJECTIVE: To 1	ready the Tug vehicle fo	r spacecraft in	tegration.
	prepare the work area as		
reparation for Tug	/Spacecraft integration	, with no kick a	stage included
n the flight confi	guration.		
ASK LOCATION: TPF	and PPF/KSC and PPF/WT	R	
	L End Work Stands		
	nsporter		
124 Cr	adles		
<u> </u>			
		<u> </u>	<u></u>
			M-HRS
MANPOWER REQUIREMEN	TS: PROPULSION TECH MECHANICAL TECH		M-HRS
	AVIONICS TECH	2	M-HRS
	ENGINEERING	0	M-HRS
	QUALITY CONTROL	2	M-HRS
	SAFETY	0	M-HRS
	OTHER	8	M-HRS

				pacecraft in	i.e	
ASK PURPOSE:	To prep	are the work area	and r	erform the f	inal work	in
preparation for	Tug/Spa	cecraft integrati	on, wi	th a kick st	age includ	led
in the flight co						
· · · · · · · · · · · · · · · · · · ·						
						<del></del>
ASK LOCATION:	TPF and	PPF/KSC and PPF/	WIR			
TASK EQUIPMENT:	191 Er	nd Work Stands	118	C/O Cable K	it	
183	Transpo	orter	118	Signal Cond	Unit	
124	Cradle		185	Umbilical K	it	
168						
		raft Sim		`		
127	DMTS			<u></u>		
155	Power	Sys Test Set				
119	Comm S	ys Test Set				
MANPOWER REQUIRE	MENTS:	PROPULSION TECH		4	M-HRS	
		MECHANICAL TECH		8	M-HRS	
		AVIONICS TECH		4	M-HRS	
		ENGINEERING		0	M-HRS	
		QUALITY CONTROL		2	M-HRS M-HRS	
		SAFETY		<u>2</u> 8	M-HRS	
		OTHER			м-пкэ	

K TITLE: MATE TOO A	n the Tug/Spacecraft	integration.		
K OBJECTIVE: To perform	1 012 1 1 1 1			
			for a delivery	
SK PURPOSE: To mate	the Tug vehicle and	the Spacecratt		
light.				
	:			
ASK LOCATION: TPF and	PPF/KSC and PPF/WTR			
ASK LOCATION:	ings and Tag Lines			
TASK EQUIPMENT: 140 ST				
191 Work St				
183 Transpo	orter			
124 Cradle				
150 <u>P/L Ad</u>	apter Handling Kit			
MANPOHER REQUIREMENTS:	PROPULSION TECH	0	M-HRS	
MANPOWER REGORDER	MECHANICAL TECH	4/7	M-HRS M-HRS	
-	AVIONICS TECH	0	M-HRS	
	ENGINEERING	1	M-HRS	
	QUALITY CONTROL	1	M-HRS	
	SAFETY	3	M-HRS	
INTERFACE REQUIREMENTS				
	•			

<del>60</del>0-75

T/	verify the launch resu	diness of the T	tig/Snacecraf	t interfac
ASK OBJECTIVE:	verify the launch read		ag/opacectar	- Interior
		· · · · · · · · · · · · · · · · · · ·		·····
				•
ASK PURPOSE: To	test and establish the	flight readine	ess of the Tu	g/Spacecr
interfaces (both )	nardware and software)			
				<del></del>
·			<del>- 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1</del>	
· · · · · · · · · · · · · · · · · · ·				
		· ·	,	**
				· · · · · · · · · · · · · · · · · · ·
ASK LOCATION: T	PF and PPF/KSC and PPF/	WI'K	<u> </u>	
	· · · · · · · · · · · · · · · · · · ·			
ASK EQUIPMENT: _	127 Telemetry Ground	Station		
ASK EQUIPMENT: _		,		
ASK EQUIPMENT: _	127 Telemetry Ground	,		
ASK EQUIPMENT: _		,		
ASK EQUIPMENT:				
-			M-HRS	
-			M-HRS M-HRS	
-	NTS: PROPULSION TECH _ MECHANICAL TECH _ AVIONICS TECH _	0 0 0 21	•	
-	NTS: PROPULSION TECH	0 0 21 14	M-HRS	
-	NTS: PROPULSION TECH	0 0 21 14 0	M-HRS M-HRS	
-	NTS: PROPULSION TECH	0 0 21 14 0	M-HRS M-HRS M-HRS	
ASK EQUIPMENT:	NTS: PROPULSION TECH	0 0 21 14 0	M-HRS M-HRS M-HRS M-HRS	

SK OBJECTIVE: To ver ehicle for transports	rify the cleanliness of		
ASK PURPOSE: To ch	eck the particle count	er and verify the	cleanliness and
then to place the cov	er on the vehicle to i	nsure the 100,000	class cleanlines
is maintained during	local transportation o	f the vehicle.	
TASK LOCATION: TPF	and PPF/KSC and PPF/WT	R	
rask equipment:			
			<del></del>
,			
	: PROPULSION TECH	0	M-HRS
MANPOWER REQUIREMENTS		5	_ M-HRS
	AVIONICS TECH	0	_ M-HRS
	ENGINEERING	2	_ M-HRS
	QUALITY CONTROL	5	_ M-HRS
	SAFETY	1	_ M-HRS
	OTHER	14	_ M-HRS
INTERFACE REQUIREMEN	TS:		
THICK YOU WEGGE WENT			

76-D-77

	ER FSE to MCF				
ASK OBJECTIVE: To t	ransfer the F	light Support	Equipment to	the Orbite	er MCF 1
integration into the	Orbiter.				<del>, , , , , , , , , , , , , , , , , , , </del>
ASK PURPOSE: Trai	nsfer the FSE	for installat	ion and main	tain the cle	anline
of that equipment d	uring the tran	sfer.			
			·		·
TASK LOCATION: TPF	to MCF/KSC, I	PPF to MCF/WTF	₹		
	4 Equipment V		-		
There exertises				<del></del>	
192	2 Security Ve	nicle			
				· · · · · · · · · · · · · · · · · · ·	
				<del></del>	
MANPOWER REQUIREMEN	TS: PROPULSIO	N TECH	0	M-HRS	
	MECHANI CA	L TECH	0	M-HRS	
	AVIONICS	TECH	0	M-HRS	
	ENGINEERI	NG	0	M-HRS	
	QUALITY C	ONTROL	3	M-HRS	
	SAFETY	***************************************	0	M-HRS	
	OTHER	•	15/17	M-HRS	
INTERFACE REQUIREME	NTA -				

SK TITLE: INSTALL FS	E IN CABIN (CONSOLE) (	2.3.2.1.a)	
SK TITLE:	ill the payload console	in the Payloa	d Specialist
tation of the Orbiter v	rehicle.		
CACTOR OF VIII OF			
			_
ASK PURPOSE: To insta	all the payload console	and verify th	e interfaces wit
the Orbiter system.		·	
			·
TACK LOCATION. MCF/KSC			
TASK EQUIPMENT:			
			-
·			
<del></del>			
	PROPULSION TECH	0	M-HRS
MANPOWER REQUIREMENTS:	MECHANICAL TECH		M-HRS
	AVIONICS TECH	6	_ M-HRS
	ENGINEERING	0	M-HRS
		1	M-HRS
	CRIALITY CUNTRUL		
	QUALITY CONTROL	0	M-HRS
	SAFETY	0 3	-
CHERRY OF DESIGNATION	SAFETY	3	M-HRS M-HRS
INTERFACE REQUIREMENTS	SAFETY	3	M-HRS M-HRS

# D-79

	Las Aba COUCEC manua	and on MD mine	ione
SK OBJECTIVE: To inst			
SK PURPOSE: To ins	tall the COMSEC into	the Orbiter sys	tem for the DOD
issions.			
SK LOCATION: MCF/KS	C and WTR		
SK EQUIPMENT:			
DK EQUITALITY			<del></del>
			<del></del>
			<del>,</del>
			<del></del>
	PROPULSION TECH	0	M-HRS
	PROPULSION TECH MECHANICAL TECH	0 1.5	M-HRS M-HRS
	PROPULSION TECH MECHANICAL TECH AVIONICS TECH	0	M-HRS M-HRS M-HRS
	PROPULSION TECH MECHANICAL TECH AVIONICS TECH ENGINEERING	0 1.5 3.5	M-HRS M-HRS
	PROPULSION TECH MECHANICAL TECH AVIONICS TECH	0 1.5 3.5	M-HRS M-HRS M-HRS M-HRS
<del></del>	PROPULSION TECH MECHANICAL TECH AVIONICS TECH ENGINEERING QUALITY CONTROL	0 1.5 3.5 1	M-HRS M-HRS M-HRS M-HRS M-HRS

DK OBJECTIVE.	re the Orbiter for	and have		
he necessary support eq	uipment in the paylo	Jan Day •		
ASK PURPOSE: To insta	dl the Flight Suppo	rt Equipment	required by	the paylo
into the Orbiter Payload	l Bay.			
into the order				
TASK LOCATION: MCF/KSC	and WTR			
TASK EQUIPMENT:		<del></del>		
<del></del>				
			M-HRS	
MANPOWER REQUIREMENTS:	PROPULSION TECH		M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH	1 5 5	<del></del>	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH		M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH	5 5	M-HRS M-HRS M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING	5 5 4 1	M-HRS M-HRS M-HRS M-HRS M-HRS	
	MECHANICAL TECH	5 5 4 4 1	M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS	
MANPOWER REQUIREMENTS:  INTERFACE REQUIREMENTS	MECHANICAL TECH	5 5 4 4 1	M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS	

TASK TITLE:	<del></del>	VERIFY FSE INTERFAC	CES (2.3.3)	<u> </u>	***	
TASK OBJECTIVE:	To es	stablish the test re	eadiness of	the Pa	ayload sup	plied
Flight Support	Equip	ment.		<del></del>	<del></del>	
TASK PURPOSE:	This	is a preliminary st			readiness	certification
of the payload.	,					
·						
TASK LOCATION:		KSC and WTR				
TASK EQUIPMENT:	148	Signal Cond Unit				<del></del>
Work Edoring	185	Umbilical Kit			<del></del>	
	127	DMS Test Set				
	155	Power Sys Test Set				
	119	Comm Sys Test Set				
	118	C/O Cable Kit				
MANPOWER REQUIRE	EMENTS	: PROPULSION TECH		0	M-HRS	
		MECHANICAL TECH		0	M-HRS	
	4	AVIONICS TECH		3	M-HRS	
	•	ENGINEERING		0	M-HRS	
		QUALITY CONTROL		1	M-HRS	
		SAFETY		0	M-HRS	
		OTHER	· · · · · · · · · · · · · · · · · · ·	<u> 4</u>	M-HRS	
INTERFACE REQUIR	REMENT:	S:				
					<del></del>	
	····					

75 D-82

ASK TITLE:				TO MCF			integration	facility.
TASK PURPOSE: _	To pr	ovide	the	payload	at the	Orbiter	facility des	ignated To
the horizontal	integr	ation	of a	payload	l.			
					<del></del>			
								·.
	PPF C	т трр	-to-l	MCF/KSC.	PPF t:	MCF/WTR		
TASK LOCATION:						. <u></u>		<u> </u>
TASK EQUIPMENT:	124	Cradl	es					
	183	Trans	port	er				
	182	Tract	or					
						·		•
	123	Cover	-Tug		<del></del>	,		•
	192	Secur	itv	Vehicle	,			•
MANPOWER REQUIRE		: PRO	PULS	ION TECH		0	M-HRS	•
,			HANI	CAL TECH		0_	M-HRS	
		AVI	ONIC	S TECH		0	M-HRS	
		ENG	INEE	RING		0	M-HRS	
		QUA	LITY	CONTROL		0	M-HRS	
		SAF	ETY			0	M-HRS	
		HTO	IER		-	3/5	M-HRS	
INTERFACE REQUII	SCHOUT							

ASK TITLE: PAYLO		<del></del>		PREPARATIO					
ASK OBJECTIVE: T	o pre	pare i	for the	physical	installa	ation o	of the pa	ayload in	nto
the payload bay.	· · · · · · · · ·		<del></del>				<del></del>		
			-33						
				reparatory					
gration into the	paylo	oad bay	y, mair	itaining c	leanline	ss of	the vehic	cle.	
	···			·	·····				
		·····							
ASK LOCATION: M	CF/KS	SC and	WTR	<del></del>	<del></del>				
`		Franspo			<del></del>				
1	24 (	Cradles	5	<del></del>			<del>"</del>		
<u>1</u>	40 I	dandlir	ng Equi	ַבָּ		<del></del>			
		·				· · · · · · · · · · · · · · · · · · ·	<del></del>		
<del></del>	·····								
			<del></del>		<del></del>				
-						<del> </del>			
ANPOWER REQUIREMEN	M12:		WICAL		2		_ M-HRS		
			IICS TE		1		M-HRS M-HRS		
			IEERING		2		M-HRS		
			TY CON		0		M-HRS		
		SAFET			0		M-HRS		
		OTHER	3		19		M-HRS		
ITERFACE REQUIREME	NTC.								

ASK OBJECTIVE: The	physic	al	installation	n of	the	payload	into	the	Orbi	ter	pay
oad bay.						<del></del>					
ack puppose. To	comple	te	the physical	ins	tall	ation of	the	payl	oad i	into	th
brbiter vehicle.											
					·						
1											
						·					
ASK LOCATION: MC	F/KSC a	and	WTR								
	O Hen	474	ng Equipment								
ASK EQUIPMENT: 11	+U IIaii		ng, ngarpmene						_		
									_		
									_		
_									_		
-									_		
_	·				<u> </u>						
_									_		
_									_		
	NTC. D	PAR	ULSION TECH			2		M-HR	S		
MANPOWER REQUIREME			IANICAL TECH					M-HR	S		
	•		NICS TECH			2		M-HR	S		
	•		NEERING			2		M-HR	S		
	_		ITY CONTROL			0		M-HR	<b>S</b>		
		AFE				. 2		M-HF	เร		
•	_	)THE				3		M-HF	RS		
											*
INTERFACE REQUIREM	ients:										

VZK OB	WECTIVE:	Establi	sh the readiness o	f the pay	load/Shut	tle inter	faces prior
			operations phase.				
					<b>.</b>		and botte
ASK PL	URPOSE:	Test a	nd validate the int				
the pa	ayload ar	nd the Or	biter vehicle. The	is is the	final pay	load test	before
the in	ntegrated	i systems	test.			<u>, , , , , , , , , , , , , , , , , , , </u>	
	<u></u>						
	. <u> </u>						
		VOT /VC	SC and WTR			<del></del>	
rask L	OCATION:						
TASK E	EQUIPMENT	161	Prop Pneu Console		Signal Co		
		185	Umbilical Kit	163	Prop or I	neu Cont	Console
		117	C/O Access Kit	301,	305, 307	COMPUTER	PROGRAMS
		127	DMS Test Set				
		155	Power Sys Test Set				
		119	Comm Sys Test Set				
			C/O Cable Kit			· · · · · · · · · · · · · · · · · · ·	
MAN 50	WER REQU				27	M-HRS	
FARPU	WER REQU	I KCHCH ( 3 .	MECHANICAL TECH		8	M-HRS	
			AVIONICS TECH		18	M-HRS	
			ENGINEERING		36	M-HRS	
			QUALITY CONTROL		18	M-HRS	
			SAFETY		0	M-HRS	
			OTHER		8 .	M-HRS	
TNTED	RFACE REQ	HIREMENTS	S:				

Way Iller.		/PAYLOAD INTEGRATED			
ASK OBJECTIVE:	Estab	lish the launch read	diness of the	integrated laund	ch vehicle
		leasing the payload			
ASK PURPOSE: _	To va	alidate the integrat	éd system int	egrity prior to	the
final launch op	eratio	ons.			
					<del> </del>
			<del></del>		
ASK LOCATION:	Laun	ch Pad/KSC and WTR			
TASK EQUIPMENT:	148	Signal Conditionin	g Unit 185	Launch Umbilical	L Sys
•	176	Subsys Monitor Cons	sole 155	Power Sys Test S	Set
	118	C/O Cable Kit	129	Digit. Events Re	ec.
		Telemetry Ground S	tation 189	Voice & Timing S	Svs
e <sup>*</sup>	128	•			
•	127	DMS Test Set	190		
			301.	305. 307 COMPUT	ER PROGRA
	145	Launch Console			
MANPOWER REQUIR	EMENTS	: PROPULSION TECH	8	M-HRS	
		MECHANICAL TECH	36	M-HRS	
		AVIONICS TECH	18	M-HRS	
		ENGINEERING	30	M-HRS	
		QUALITY CONTROL	24	M-HRS	
•		SAFETY	4	M-HRS	
		OTHER	8	M-HRS	
INTERFACE REQUI	REMENT	S:			
		•			

K TITLE: MONITOR STORABLE ACPS (2.4.1.a		
K OBJECTIVE: To continually verify the inte	grity of the	storable ACPS,
rom integration through launch.		
ASK PURPOSE: To respond to safety requirem		e the integrity o
the storable ACPS and verify no leakage in th	e system.	
TASK LOCATION: MCF, VAB, PAD/KSC and WTR		
TASK LUCATION:	nle	
179 Signal Conditioning Un		
146 Launch Umbilical System	<u></u>	
118 C/O Cable Kit	,	
155 Power Sys Test Set		
127 DMS Test Set		
128 Telemetry Ground Stat	ion	
MANPOWER REQUIREMENTS: PROPULSION TECH	84	M-HRS
MECHANICAL TECH		M-HRS
AVIONICS TECH	00	M-HRS M-HRS
ENGINEERING	00	M-HRS
QUALITY CONTROL SAFETY	84	M-HRS
OTHER	0	M-HRS
<b>•</b> • • • • • • • • • • • • • • • • • •		

To To							_
rask objective: 🚆	compl	ete the umbilical	hcokup at th	ne launc	h pad of	the Tug	-
unique umbilicals.	•				<u></u>		
TICK DUDDOCE TO	o prepa	are for the launch	pad prelaun	ch servi	cing of	the Tug	
vehicle and estable							_
vehicle and estab	lish C	ne unbilical bjbo.					_
							<u> </u>
						,	
	<del> </del>						
	aunch	Pad/KSC and WTR	<del> </del>		•		_
TASK LUCATION:							
TASK EQUIPMENT:	185 Launch Umbilical Svs 162 Prop Pneu Console						
•	118 C	O Cable Kit	117	C/O Acc	ess Kit		
•	148 S	ignal Conditionin	z Unit	· · · · · · · · · · · · · · · · · · ·			
· •	176 Si	ubsys Monitor Cons	sole 163	Prop of	r Pneu Co	ont. Cons	sol
:	127 <u>D</u>	S Test Set		. <u> </u>			
•		ver Sys Test Set					
•							
•		DAS GND Station			M UDC		
MANPOWER REQUIREM	ENTS:	PROPULSION TECH _ MECHANICAL TECH			M-HRS M-HRS		
		AVIONICS TECH	<u> </u>		M-HRS		
		ENGINEERING	6		M-HRS		
		QUALITY CONTROL	2.5		M-HRS		
		SAFETY	1.5	<u> </u>	M-HRS		
		OTHER	0		M-HRS		
INTERFACE REQUIRE	MENTS:						
				<del></del>			

SK OBJECTIVE: _F	erform the final prelaunch	servicing on t	the fug ventcle for
he non-cryogenic	systems.		
ASK PURPOSE:	Complete the prelaunch servi	cing for the	Tug vehicle pneumatic
system.			
5,500			
		·	
	Launch Pad/KSC and WTR		
TASK LOCATION:	158 Prop Loading Console	162 Pro	p Pneu Console
TASK EQUIPMENT:	176 Subsys Monitor Console	e 129 Dig	it Events Recorder
		0	lemetry Ground Station
	148 Signal Conditioning U		op or Pneu Cont. Conso
•		305, 306	COMPUTER PROGRAMS
	185 Launch Umbilical Sys		
		8	M-HRS
MANPOWER REQUIR	EMENTS: PROPULSION TECH MECHANICAL TECH	13	M-HRS
	AVIONICS TECH	13	M-HRS
	ENGINEERING	6	M-HRS
	QUALITY CONTROL	3	M-HRS M-HRS
	SAFETY OTHER	0	M-HRS
INTERFACE REQUI			

ANK IIILE:		ERVICE AT PAD (C			43.	Mary arrivation of the
ASK OBJECTIVE:	Perfo	rm the final pre	elaunch serv	ricing	on the	Tug cryogenic
system.						
TASK PURPOSE:	To co	mplete the prel	aunch activ	ities	for the	Tug vehicle
including: a.	Cry	ogenic System P	urges			
<b>b.</b>	Cry	ogenic Loading	and Repleni	sh		
c.	Fir	nal Software Con	stants Load	ed		
		<u> </u>				
				,		
		/	mp			
TASK LOCATION:	Laun	ch Pad/KSC and I				Whiliam Sva
TASK EQUIPMENT:	125	Cryo Loading C	omplex	185		Umbilical Sys
				162		neu Console
•	176	Subsys Monitor	Console	129	Digit	Events Recorder
,	148	Signal Conditi	oning Unit	128	Teleme	try Ground Station
305, 306	118	C/O Cable Kit				A * * A
COMPUTER PROGRAMS	155	Power Sys Test	Set	163	Prop or	Pneu Cont. Consol
	127	DMS Test Set				
*************************************			FCH	10	0	M-HRS
MANPOWER REQUIRE	inen i s	MECHANICAL T				M-HRS
		AVIONICS TEC		1	6	_ M-HRS
		ENGINEERING			8	_ M-HRS
		QUALITY CONT	ROL		6	_ M-HRS M-HRS
		SAFETY OTHER			<u>2</u> 6	_ M-HRS
		-		. <u></u>	· · · · · · · · · · · · · · · · · · ·	<b>-</b> '
INTERFACE REQUI	remen'	TS:				

TASK OBJECTIVE:  Final activation of the Tug fuel cells*  TASK PURPOSE:  To complete the prelaunch activation of the Tug fuel  TASK LOCATION:  Launch Pad/KSC and WTR  TASK EQUIPMENT:  148 Signal Conditioning Unit 125 Cryo Loading Cor  176 Subsys Monitor Console:  185 Launch Umbilical  118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS  ONALITY CONTROL 0 M-HRS	<del></del>
TASK LOCATION: Launch Pad/KSC and WTR  TASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Con  176 Subsys Monitor Console: 185 Launch Umbilical  118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
ASK LOCATION: Launch Pad/KSC and WTR  ASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Condition 176 Subsys Monitor Console 185 Launch Umbilical 118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS AVIONICS TECH 3 M-HRS ENGINEERING 6 M-HRS	·
ASK LOCATION: Launch Pad/KSC and WTR  ASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Condition 176 Subsys Monitor Console 185 Launch Umbilical 118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS AVIONICS TECH 3 M-HRS ENGINEERING 6 M-HRS	<del></del>
ASK LOCATION: Launch Pad/KSC and WTR  ASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Condition 176 Subsys Monitor Console: 185 Launch Umbilicated 118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS MECHANICAL TECH 0 M-HRS AVIONICS TECH 3 M-HRS ENGINEERING 6 M-HRS	·
TASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Condition 126 Subsys Monitor Console 185 Launch Umbilical 127 DMS Test Set  127 DMS Test Set  128 Telemetry Ground Station  TANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	cells
ANPOWER REQUIREMENTS: PROPULSION TECH  AVIONICS TECH  AVIONICS TECH  AND AND AND AND AND AND AND AND AND AND	<del></del>
TASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Condition 126 Subsys Monitor Console 185 Launch Umbilical 127 DMS Test Set  127 DMS Test Set  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
ASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Condition 126 Subsys Monitor Console 185 Launch Umbilical 127 DMS Test Set  127 DMS Test Set  128 Telemetry Ground Station  128 Telemetry Ground Station  128 MECHANICAL TECH 3 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	·
ANPOWER REQUIREMENTS: PROPULSION TECH  AVIONICS TECH  AVIONICS TECH  AND AND AND AND AND AND AND AND AND AND	
TASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Condition 126 Subsys Monitor Console 185 Launch Umbilical 127 DMS Test Set  127 DMS Test Set  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
TASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Condition 126 Subsys Monitor Console 185 Launch Umbilical 127 DMS Test Set  127 DMS Test Set  128 Telemetry Ground Station  TANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
TASK EQUIPMENT: 148 Signal Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Conditioning Unit 125 Cryo Loading Condition 126 Subsys Monitor Console 185 Launch Umbilical 127 DMS Test Set  127 DMS Test Set  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	<del></del>
176 Subsys Monitor Console 185 Launch Umbilical  118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  VANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	_
118 C/O Cable Kit  127 DMS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
127 DNS Test Set  155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  WANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	l Sys
155 Power Sys Test Set  129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
129 Digit Events Pecorder  128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
128 Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
Telemetry Ground Station  MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
MANPOWER REQUIREMENTS: PROPULSION TECH 3 M-HRS  MECHANICAL TECH 0 M-HRS  AVIONICS TECH 3 M-HRS  ENGINEERING 6 M-HRS	
MECHANICAL TECH 0 M-HRS AVIONICS TECH 3 M-HRS ENGINEERING 6 M-HRS	
AVIONICS TECH 3 M-HRS ENGINEERING 6 M-HRS	
Eliastication and a second	
AUGUSTAN CONTROL O MINE	
QUALITY CONTROL O M-HRS	*
SAFETY 0 M-HRS	
OTHER 3 M-HRS	
INTERFACE REQUIREMENTS: *Applies to only those configurations with	
cells included.	fuel

SK TITLE:	TUG SERVICE AT PAD (CRYO)	(2.4.3.b)
SK OBJECTIVE:	Final loading of cold heli	um system of the Tug*
ASK PURPOSE:		activities of the Tug cold helium
pressurization s	system.	
ASK LOCATION:	Launch Pad/KSC and WTR	
TASK EQUIPMENT:		162 Prop Pneu Console
	176 Subsys Monitor Cons	ole 129 Digit Events Recorder
	148 Signal Conditioning	Unit 128 Telemetry Ground Station
	118 C/O Cable Kit	147 LH2-He Heat Exchanger
	155 Power Sys Test Set	125 Cryo Loading Complex
	127 DMS Test Set	163 Prop or Pneu Cont Consol
•	185 Launch Umbilical Sy	'S
MANPOWER REQUIR	EMENTS: PROPULSION TECH	4 M-HRS
MANYUWEK KEQUIN	MECHANICAL TECH _	O M-HRS
	AVIONICS TECH	M-HRS
	ENGINEERING	6 M-HRS
	QUALITY CONTROL _	O M-HRS
	SAFETY	O M-HRS
	OTHER _	O M-HRS
INTERFACE REQUI	REMENTS: *Applies only t	o those vehicles using the cold heli
ontion.		

SK OBJECTIVE:	To monitor final launch redli	ned parameters.	·
	l		
	To establish the launch readi	ness complianc	e of the Tug
ISK PURPOSE: _	TO GROUDITION OLIC COMPANY		
rehicle.			
	-		
		•	
ASK LOCATION:	LCC/KSC and WTR		
TASK EQUIPMENT:	176 Subsys Monitor Console	129 Digit	<u>Events</u> Recorder
	179 Terminal Room Equip	189 Voice	% Time Sys
	146 Launch Umbilical Sys	190 Wideb	and Rec.
	118 C/O Cable Kit		
•	155 Power Sys Test Set		
v	128 Telemetry Ground Static		
MANPOWER REQUIF			M-HRS M-HRS
	MECHANICAL TECH AVIONICS TECH	0 0	M-HRS
8	ENGINEERING	154	M-HRS
·	QUALITY CONTROL	Ó	M-HRS
	SAFETY	0	M-HRS
	OTHER	0	M-HRS
INTERFACE REQU	T DEMENTS •		

K OBJECTIVE: TO	remove a payload from	the payload bay of	the Orbiter at
e Launch Pad			
OM DUDGGG.	Required for payload ch	nangeout. Assumes	the cleanliness
rotection will be	provided for the paylo	ad being removed.	<u></u>
		· ′	
			·
ASK LOCATION: LE	unch Pad/KSC and WTR		
rask equipment: 1	91 Work Platforms		
2	23 Cover-Tug		
<u> </u>	40 Handling Equip		
	.83 Transporter		
-	124 Cradles		
-			
<u>-</u>	182 Transporter Tracto	r	·
, ·			<del></del>
MANPOWER REQUIREME		4 .	_ M-HRS
	MECHANICAL TECH	10 4	_ M-HRS
	AVIONICS TECH	<u>4</u> 4	_ M-HRS M-HRS
	ENGINEERING	3	_ M-HRS
	QUALITY CONTROL _ SAFETY	3	M-HRS
	OTHER	23	M-HRS
•	VIIII .		-

TASK TITLE: PAIN TASK OBJECTIVE: Pro	onoro f	or the removal o	r installa	tion of	a payload	into	the
Orbiter payload ba	y at th	e launch pad.			<u></u>		<u></u>
TASK PURPOSE: To	provi	le the physical a	ccess and	the env	ironmental	prot	ectio
required for on-pa	d payle	oad changeout.				4	
				·····		<u>-</u>	
				· · · · · · · · · · · · · · · · · · ·			
						<del></del>	
		ad/KSC and WTR				<del></del>	
TASK LOCATION:	aunen r	AU VOC BUIL HIV		<del> </del>		<del></del>	
TASK EQUIPMENT: 1	91 Wo	rk Platforms			<del></del>		
-							
-					<del></del>		
_							
•							
-					<del></del>		
• • ·							
MANPOWER REQUIREM		PROPULSION TECH	-	0.5	M-HRS		
		MECHANICAL TECH		0.5	M-HRS M-HRS		
	•	AVIONICS TECH		0.5	M-HRS		
		ENGINEERING		0.5	M-HRS		
		QUALITY CONTROL SAFETY		0	M-HRS		
		OTHER		2	M-HRS		
	いたいてた。	•			<del></del>		
INTERFACE REQUIRE	MEN 12:						

ASK TITLE: PAY					
ASK OBJECTIVE: $\underline{{}^{\mathrm{T}_{0}}}$	o inst	all a payload into	the payload	bay of the C	rbiter at
the launch pad.					
					_
ASK PURPOSE:T	he ver	tical installation	n of a payload	during the	payroad change
out operation.					
		·			
		<u> </u>			
			. •		
	Counch	Pad/KSC and WTR			
rask Location:	Launen	Pad/Abc and win	<u> </u>		
TASK EQUIPMENT:	117 C	/O Access Kit			-
	140 <u>Ha</u>	ndling Rauinment			_
•		g Support Kit Vert		<u> </u>	_
•					_
:	191 Wo	rkstand Kit			-
	<u>.</u>				-
					_
					·
MANDOUED DEGUIDEN	ENTS.	PROPULSION TECH	2	M-HR	- S
MANPOWER REQUIREM	EN13.	MECHANICAL TECH	15	M-HR	S
		AVIONICS TECH	2	M-HR	S
		ENGINEERING	2	M-HR	S
		QUALITY CONTROL	0	M-HR	s
		SAFETY	2	M-HR	S
		OTHER	5	M-HR	S
***************************************	MENTO	•			
INTERFACE REQUIRE	LITE IT I D				

K TITLE:	ANSFER PAYLOAD TO PAD (2.	to the launch pad f	or payload
SK OBJECTIVE: _T	o transier a new payrous		
hangeout.			
ASK PURPOSE:	To provide a clean payloa	d at the launch pad	during payload
WK 1011100			
changeout.			
	Launch Pad/KSC and WTR		
TASK LOCATION:			
TASK EQUIPMENT:	124 Cradles		<del></del>
	122 Cover-Spacecraft		
	123 Cover-Tug		
	140 Handling Equip		
	<del></del>		
· · · · · · · · · · · · · · · · · · ·	154 Portable Cover-Pura	re Unit	
	182 Tractor		
	183 Transporter		
MANPOWER REQUIR	EMENTS: PROPULSION TECH	0	_ M-HRS
PHILONEIC WESTER	MECHANICAL TECH		_ M-HRS
	AVIONICS TECH	0	_ M-HRS
	ENGINEERING	4	_ M-HRS
	QUALITY CONTROL	0	M-HRS
	SAFETY	0	_ M-HRS M-HRS
	OTHER	24 /28	M-UV
INTERFACE REQUI	DEMENTS.		

ASK TITLE: TUG GROUND	SAFING AT SAFING	AREA (3.1.1)		
ASK OBJECTIVE: To ven	, drain, and purge	e the cryogeni	c systems of t	he Space
Tug, including high pro				
	2			
ASK PURPOSE: To plac	e the cryogenic sy	stems in a "sa	fe" state and	to prepare
these systems for any	required maintenan	ce action.		
				· · · · · · · · · · · · · · · · · · ·
TASK LOCATION: Shutt	e Safing Area/KSC	or WTR		
				• .
TASK EQUIPMENT: 191	Workstands			
·				
		161	Prop Pneu Cor	
Hydro	gen Gas Disposal S	ystem 163	Prop or Pneu	Cont. Consc
139 Gas S	ampling Equipment			
	able Kit Partial			
·			M-HRS	
MANPOWER REQUIREMENTS:		0	M-HRS	
	MECHANICAL TECH AVIONICS TECH	8	M-HRS	
	ENGINEERING	6	M-HRS	NO LIQUID
	QUALITY CONTROL	8	M-HRS	RESIDUALS
	SAFETY	8	M-HRS	
	OTHER	20	M-HRS	
TATEDEACE DECHITOCHENTS	. The Shuttle	must remain at	the Safing A	rea until
INTERFACE REQUIREMENTS	Task assumes succ			
completion of task.	185K 85SWaes Succ	castar sarring		

ISK TITLE: TUG GR	OUND SAFING AT SAFING A	KEA (3.1.1.8)	cyctems of th	e Space
	vent, drain, and purge	the cryogenic	: systems of on	o opaco
lug, including high	pressure gas vessels.			
ASK PURPOSE: To I	place the cryogenic syst	ems in a "sa	fe" state for h	nandling
of the Tug, and to	prepare these systems i	for any requi	red maintenance	action.
				· · · · · · · · · · · · · · · · · · ·
		·		
TASK LOCATION: Sh	uttle Safing Area/KSC o	f WTR		
TASK EQUIPMENT: 19	)l Workstands			
•	abilical Kit			
· · · · · · · · · · · · · · · · · · ·		161	Prop Pneu Con	sole
— H	ydrogen Gas Disposal Sys	stem 126	Cryo Tank Tru	cks
	as Sampling Equipment		Prop or Pneu	Cont. Conso
_				
118 0	/O Cable Kit (Partial)			
MANPOWER REQUIREME		0	M-HRS M-HRS	
	MECHANICAL TECH	12	M-HRS	LIQUID
	AVIONICS TECH _ ENGINEERING	10	M-HRS	RESIDUAL
	QUALITY CONTROL _	10	M-HRS	
	SAFETY _	10	M-HRS	
	OTHER _	20	M-HRS	
	_	remain at th	e Safing Area	until
INTERFACE REQUIREM	MENTS: The Shuttle must	Temerii ee or		
completion of ta	sk.		·	

SK OBJEC	TIVE:	Transfe	er of the Space Tu	g to the	Storable 1	Propellant	Facilit
SK PURPO	SE: _	To provi	ide the Tug at the	Facilit	y location	where th	ne storat
ropellan	ACPS	can be	placed in a "safe	e" state.	<del> </del>		
		<del></del>					
<del> </del>	· · · · ·				<u></u>		
	,	<u> </u>				<u></u>	
ISK LOCAT	ION:		SPF/KSC and WTR			•	
SK EQUIP		123	Tug Cover				
·	183	Transp	orter				
	182	Tracto	r	,			
	- - 01:			<del></del>			
	124	Cradle					
	191	Works	tands			<del></del>	
ANPOWER R	EQUIRE	EMENTS:	PROPULSION TECH		0	M-HRS	
			MECHANICAL TECH		1.	M-HRS	
	•		AVIONICS TECH		0	M-HRS	
			ENGINEERING		0	M-HRS	
			QUALITY CONTROL		0	M-HRS	
			SAFETY		/17	M-HRS	
			OTHER		/ ÷ l	M-HRS	
NTEDEACE	REOUIF	REMENTS:	NONE				

		SAFING (3.1.3.a) , drain, purge, and l	eak check the	bipropellant ACPS
K OBJECTIVE: _	To vent	, drain, purge, and i	ear cheer one	
the Space Tug.	•			
SK PURPOSE:	To place	e the ACPS in a "safe"	state and to	prepare the system
or any required	mainte	nance action. Also,	to identify a	system which is leaking
		duled maintenance.		
id will require	unsche	dured morning		
ASK LOCATION:	Storabl	e Propellant Facility	r/KSC and WTR	
		S Loading Access Kit		
ASK EQUIPMENT:	112 A	D DORGING Access 121		<del></del>
				<del></del>
	Two Per	rsonnel Protection (S	CAPE)	<del></del>
139	Gas Sa	mpling Equipment	191	<u>Workstand</u>
161	Pneuma	tic Console	148	Signal Cond Unit
113	Two Pr	opellant Servicers		Portable Cleanliness
MANPOWER REQUIRE	EMENTS:	PROPULSION TECH	16	M-HRS M-HRS
	•	MECHANICAL TECH	35	M-HRS
		AVIONICS TECH	42	M-HRS
		ENGINEERING	22	
		QUALITY CONTROL	51	M-HRS
		SAFETY	88	M-HRS
		OTHER		M-HRS
		Mir This must make	in at the SPF	until completion of
INTERFACE REQUI	REMENTS:	The Tug must rema	In at one see	

ASK OBJECTIVE: To	vent,	drain, purge, and	leak check the	bipropellant ACPS
f the Space Tug.				
ASK PURPOSE: To	place	e the ACPS in a "saf	'e" state and	to prepare the system
		nance action. Also,		
البراط بالشاع والماجو الماج بالماد ومواد ويوجون				
rom leaking for t	insche	duled maintenance.		
			<u> </u>	
ASK LOCATION: S	afing	Area/KSC and WTR		
ASK EQUIPMENT:	L12 A)	PS Loading Access Ki	t	
Non Edottient			191	Workstands
=				
•		2 Protection (SC	APF)	
•		onnel Protection (SC		
139	as Sar	pling Equipment	······································	Fortable Cleanliness Te
161 F	neumai	cic Console	163	Prop or Pneu. Cont. Con
113	2 Prop	ellant Servicers		
MANPOWER REQUIREM	ENTS:	PROPULSION TECH	16	M-HRS
		MECHANICAL TECH	35	M-HRS
		AVIONICS TECH	42	M-HRS
		ENGINEERING	22	M-HRS
		QUALITY CONTROL	21	M-HRS
		SAFETY	15	M-HRS
		OTHER	22	M-HRS
INTERFACE RECUIRE	MENTS:	The Shuttle must	remain at the	safing area for this
MITCHINGE MEGALIM				

the Space Tug	vent,	drain, purge, and				
the Space 148	<u> </u>					
SK PURPOSE: T	o place	the ACPS in a "sa	fe" state a	nd to	prepare	the system
or any required	mainten	ance action. Also	, to identi	fy a	system le	ak failure
which will requir	e unsch	eduled maintenance	· .			
mich will require						
	·			المستجمعين		
		e Propellant Facil	ity/KSC and	WTR		
TASK EQUIPMENT:	112 AF	S Loading Access	<u> </u>	183	Transport	er
						,,,,
			(	182	Tractor	
	Two Per	sonnel Protection	(SCAPE)	123	Covers	
139	Gas San	apling Equipment		109		Cleanliness Ten
161	Pneuma	tic Console		192	Security	Vehicle
113	Propel	lant Servicer				•
	EMENTS:	PROPULSION TECH	10		M-HRS	
MANDOWER REQUIR		MECHANICAL TECH	24		M-HRS	
MANPOWER REQUIRE		AVIONICS TECH	15		M-HRS M-HRS	
MANPOWER REQUIRE		ENGINEERING	16		M-RKS M-HRS	
MANPOWER REQUIR			10		M-HRS	
MANPOWER REQUIRE		QUALITY CONTROL				<b>\</b>
MANPOWER REQUIR		SAFETY	5			
		•	5		M-HR	5

N UDULUIS TO THE	ent, drain, purge, and			
PS of the Space lug				
	ace the ACPS in a "sa	ea" state and	to prepare the syst	,em
K PURPOSE: To pl	ace the ACPS in a sa	134169	e system leak failu	ire_
r any required main	tenance action. Also	to identity	a 3,000	
nich will require un	nscheduled maintenance	<u> </u>		
		,		
SK LOCATION: _Safi	ng Area/KSC and WTR			
ASK EQUIPMENT: 112	APS Loading Access	Kit		
		·		
	ersonnel Protection (S	SCAPE)		. •
				••
	Sampling Equipment	./2	Prop or Pneu. Cont.	Cons
161 <u>Pne</u>	umatic Console	163	Prob of Theu.	, , ,
113 ACF	S Servicer			
MANPOWER REQUIREMENTS:	rs: propulsion tech _	10	M-HRS	
MANPONER REGULATION	MECHANICAL TECH	24	M-HRS	
	AVIONICS TECH	15	M-HRS M-HRS	
	ENGINEERING	16	M-HRS	
	QUALITY CONTROL	10	M-HRS	
	SAFETY .	10	M-HRS	
	OTHER .	14		_
INTERFACE REQUIREME	NTS: The Shuttles m	mst remain et	the Safing Area 10	Γ
• • • • • • • • • • • • • • • • • • • •	•		. 3	

K OBJECTIVE: Transf	er of returning payloa	d to the Store	able Propellant
eility.			
au pupposs	ovide the payload at th	e facility lo	cation where the
torable propellant s	ystems can be placed in	i a sale sou	
·			
ASK LOCATION: MCF	co SPF/KSC and WTR	·	
ASK EQUIPMENT: 123	Tug Cover		
	ecraft Cover		
183 Tran	sporter		
182 Trac	tor		
124 Crad	les		
ANPOWER REQUIREMENTS	: PROPULSION TECH	0	M-HRS
MULDNEK KEGOTKENEN	MECHANICAL TECH	1	M-HRS
	AVIONICS TECH	0	M-HRS
	ENGINEERING	2	M-HRS
	QUALITY CONTROL	0	M-HRS
	SAFETY	0	M-HRS
	OTHER	12/22	M-HRS
INTERFACE REQUIREMENT	TS: Manpower requiremen	its are a func	tion of Spacecraft
safing requirements			

		G (3.1.5.a) drain, purge, and	leak check t	he bi	ipropellant ACPS
f the Space Tug	With th	e spacecraft attac			
			·		
SK PURPOSE:	To place	the ACPS in a "se	fe" state a	nd to	prepare the system
or any required	mainter	nance action. Also	, to identi	fy a	system which is leaking
		iuled maintenance.			
				<del></del>	
			4		
ASK LOCATION:	Storabl	e Propellant Facil	ity/KSC and	WTR	
ASK EQUIPMENT:	112 AF	S Loading Access K	it	185	Umbilical Kit
	:			183	Transporter
	113 AI	S Servicer		182	Tractor
		rsonnel Protection	(SCAPE)	123	Covers
139		npling Equipment		163	Prop or Pneu. Cont. Con
		tic Console		192	Security Vehicle
113		opellant Servicers			
_					M-HRS
MANPOWER REQUIRE	EMENTS:	PROPULSION TECH	•		M-HRS
		AVIONICS TECH	42		M-HRS
		ENGINEERING _	22		M-HRS
		QUALITY CONTROL	21		M-HRS
		SAFETY _	14		M-HRS
		OTHER _	14/47		M-HRS
INTERFACE DECIIT	REMENTS:	Cryogenic system	safing must	be c	completed before this
operation.					<del></del>

TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK EQUIPMENT: 112 APS Loading Access Kit  183 Transporter  182 Tractor  Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Proper or Pneumatic Console  161 Pneumatic Console  113 Propellant Servicer			drain, purge, and			····		
TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK EQUIPMENT: 112 APS Loading Access Kit  183 Transporter 182 Tractor  Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Prop or Pneumatic Console  161 Pneumatic Console 113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS	the Space Tug	with the	spacecraft accaci					
TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK EQUIPMENT: 112 APS Loading Access Kit  183 Transporter 182 Tractor  Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Prop or Pneumatic Console  161 Pneumatic Console 113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS						<del></del>		
TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK EQUIPMENT: 112 APS Loading Access Kit  183 Transporter 182 Tractor  Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Prop or Pneumatic Console  161 Pneumatic Console 113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS AVIONICS TECH 15 M-HRS QUALITY CONTROL 10 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS		·						the eystem
TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK EQUIPMENT: 112 APS Loading Access Kit  183 Transporter 182 Tractor  Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Prop or Pneumatic Console  161 Pneumatic Console  113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS QUALITY CONTROL 10 M-HRS AFETY 10 M-HRS OTHER 14/34 M-HRS	SK PURPOSE:	To place	e the ACPS in a "s	afe" state a	ind to	pre	are	the system
TASK LOCATION: Storable Propellant Facility/KSC and WTR  TASK EQUIPMENT: 112 APS Loading Access Kit  183 Transporter 182 Tractor  Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Prop or Pneumatic Console  161 Pneumatic Console  113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS	or any required	mainten	ance action. Also	, to identif	уа	syster	n le	ak Aulen Alli
ASK LOCATION:   Storable Propellant Facility/KSC and WTR								
183   Transporter   182   Tractor   182   Tractor   183   Transporter   182   Tractor   184   Tractor   185   Tractor   185   Tractor   186   Tractor   186   Tractor   187   Tractor   187   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   189								
183   Transporter   182   Tractor   182   Tractor   183   Transporter   184   Tractor   185   Tractor   185   Tractor   186   Tractor   186   Tractor   187   Tractor   187   Tractor   187   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   189								
183   Transporter   182   Tractor   182   Tractor   183   Transporter   184   Tractor   185   Tractor   185   Tractor   186   Tractor   186   Tractor   187   Tractor   187   Tractor   187   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   189								
183   Transporter   182   Tractor   182   Tractor   183   Transporter   184   Tractor   185   Tractor   185   Tractor   186   Tractor   186   Tractor   187   Tractor   187   Tractor   187   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   189								
183   Transporter   182   Tractor   182   Tractor   183   Transporter   184   Tractor   185   Tractor   185   Tractor   186   Tractor   186   Tractor   187   Tractor   187   Tractor   187   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   188   Tractor   189				:+/VSC and	WTR			
Two Personnel Protection (SCAPE) 123/122 Covers  139 Gas Sampling Equipment 163 Prot or Pneumatic Console  161 Pneumatic Console  113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS	ASK LOCATION:							
Two Personnel Protection (SCAPE)  123/122 Covers  139 Gas Sampling Equipment  163 Prop or Pneumatic Console  161 Pneumatic Console  113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS	ASK EQUIPMENT:	112 AF	PS Loading Access i	<u>Cit</u>				
Two Personnel Protection (SCAPE)  139 Gas Sampling Equipment  163 Prot or Pneumatic Console  161 Pneumatic Console  113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH MECHANICAL TECH AVIONICS TECH ENGINEERING QUALITY CONTROL SAFETY OTHER  10 M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS					183	Tran	TOOT	rter
Two Personnel Flotection (and the content of the co	•				182	Trac	tor	
139 Gas Sampling Equipment  161 Pneumatic Console  113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH MECHANICAL TECH AVIONICS TECH ENGINEERING QUALITY CONTROL SAFETY OTHER  163 Prod or Pneumatic Console  Pneumatic Console  164 Prod or Pneumatic Console  165 M-HRS M-HRS M-HRS 16 M-HRS 16 M-HRS 16 M-HRS 16 M-HRS		Two Per	sonnel Protection	(SCAPE)	123/	122	Cove	ers
113 Propellant Servicer  MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS MECHANICAL TECH 24 M-HRS AVIONICS TECH 15 M-HRS ENGINEERING 16 M-HRS QUALITY CONTROL 10 M-HRS SAFETY 10 M-HRS OTHER 14/34 M-HRS	139				163	Prov	or	Pneumatic Con
MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS  MECHANICAL TECH 24 M-HRS  AVIONICS TECH 15 M-HRS  ENGINEERING 16 M-HRS  QUALITY CONTROL 10 M-HRS  SAFETY 10 M-HRS  OTHER 14/34 M-HRS	•							
MANPOWER REQUIREMENTS: PROPULSION TECH 10 M-HRS  MECHANICAL TECH 24 M-HRS  AVIONICS TECH 15 M-HRS  ENGINEERING 16 M-HRS  QUALITY CONTROL 10 M-HRS  SAFETY 10 M-HRS  OTHER 14/34 M-HRS						<u>.</u>		
MANPOWER REQUIREMENTS: PROPOLISION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  M-HRS  10  M-HRS  10  M-HRS  M-HRS  M-HRS  M-HRS	•			10	<del></del>	M	-HRS	
AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  15  M-HRS  M-HRS  M-HRS  M-HRS  M-HRS  M-HRS  M-HRS	MANPOWER REQUIREMEN	EMENTS:						•
ENGINEERING  QUALITY CONTROL  10  M-HRS  SAFETY  10  M-HRS  OTHER  14/34  M-HRS	MANPOWER REQUIR			<del></del>		M	-HRS	
QUALITY CONTROL  10 M-HRS  SAFETY 10 M-HRS  OTHER  14/34 M-HRS	MANPOWER REQUIR		WATONIAGE I TON	16		M	-HRS	
OTHER  14/34 M-HRS  14/34 M-HRS	MANPOWER REQUIR		ENGINEERING					
UINEKlated prior to this activity	MANPOWER REQUIR					M	-HRS	
Cryo safing must be completed prior to this activity	MANPOWER REQUIR		QUALITY CONTROL	10 10		M	-HRS	<b>;</b>
INTERPACE REGULARMENTS: CLYO DAZZANS	MANPOWER REQUIR		QUALITY CONTROL SAFETY OTHER	10 10 14/34		M	-HRS -HRS	; ;

<del></del>	UG AT SAFING AREA (		
SK OBJECTIVE: To remo	ve returning Tug fr	om the Space S	huttle Orbiter Vehic
ASK PURPOSE: Remove	the Space Tug to in	nitiate the Tug	ground turnsround
perations and release	the Orbiter for its	turnaround or	erations.
peraulum um peraulum			
		·	
ASK LOCATION: Safing	Area/KSC and WTR		
	ransporter	182 Tractor	- Transporter
You adonn min			•
The state of the s	head Cranes		
140 4 Tag	Lines		<del></del>
123 Tug Co	ver		
191 Work S	tands		
124 .Cradle	<b>!S</b>		
***************************************			
 AANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS
And Out I was desired	MECHANICAL TECH	10	M-HRS
	AVIONICS TECH	0	M-HRS
	ENGINEERING	66	M-HRS
	QUALITY CONTROL	00	M-HRS
	SAFETY	22	M-HRS
	OTHER		M-HRS
INTERFACE REQUIREMENTS	•		

102 D - 109

TO THE TOP TO THE	AND THE PETITOTING THE	from the opac	e Shuttle Orbiter
K UDUECITYE. 1010	ove the returning Tug		
hicle.			
SK PURPOSE: Remov	e the Space Tug from th	ne Orbiter to	initiate the Tug
	and release the Orbite	er for its tur	naround operations
PHAPOURI OPELACIONS			
ASK LOCATION: MCF/F	SC and WTR		
	Transporter	· <del></del>	
Two (	Overhead Cranes		
140 Four	Tag Lines		
123 Tug	Cover		
191 Work	Stands		
124 Crac	lles		
ANPOWER REQUIREMENTS		0	M-HRS
MITOREN REQUIREMENTS	MECHANICAL TECH	10	M-HRS
	AVIONICS TECH	0	M-HRS
	ENGINEERING	6	M-HRS
	QUALITY CONTROL	0	M-HRS
	SAFETY	22	M-HRS
	OTHER	23	M-HRS
TERFACE REQUIREMENT	S: Task must be com	oleted by G.E.	T. of 25 hours to

Mehicle.				
				· · · · · · · · · · · · · · · · · · ·
,	the payload to initi		d turnarou	nd operation
and release the Orbite	r for its turnaround	operations.	<u> </u>	
			. <u></u>	· · · · · · · · · · · · · · · · · · ·
TASK LOCATION: Safing	Area/KSC and WTR	<u> </u>		·
FASK EQUIPMENT: 183	Transporter 12	+ Cradles		
2 Ove	rhead Cranes			- <del></del>
140 4 Tag	Lines			
123 Tug C	over			
	craft Cover			
191 Works	tands			
MANPOWER REQUIREMENTS	PROPULSION TECH	0	M-HRS	
	MECHANICAL TECH	15	M-HRS	
	AVIONICS TECH	0	M-HRS	
	ENGINEERING	6	M-HRS	
	QUALITY CONTROL	2	M-HRS M-HRS	
•	SAFETY	30	M-HRS	
	OTHER			

4 · · · · · · · · · · · · · · · · · · ·	remove	the returning Pa			
biter Vehicle	·····				
SK PURPOSE: R	emove t	he Payload from t	he Orbiter to	initiate the p	ayload
SK PURPUSE:	on	d release the Orb	iter for its t	urnaround oper	rations.
urnaround operat	ions an	d release one			
ASK LOCATION: _	MCF/KSC	and WTR			
TASK EQUIPMENT:	183 Tr	ansporter			
	Two Ove	rhead Cranes	124 Cradles		
		g Lines			
					•
123	Tug Con	rer			
122	Spacec	raft Cover			
191	Work S	tands			
			·		
	MENTS.	PROPULSION TECH	0	M-HRS	
MANPOWER REQUIRE	MENIJ.	MECHANICAL TECH	15	M-HRS	
		AVIONICS TECH	0	M-HRS	
		ENGINEERING	6	M-HRS	
		QUALITY CONTROL	0	M-HRS	
		SAFETY	2	M-HRS	
		OTHER	24	M-HRS	
		Task must be		م مسفد	c 25 hc

K OBJECTIVE: To remo	ove the display and con	ntrol equipment	from the
turning Orbiter Vehic	ele.		
	tiste the turnaround o	nerations of th	e Tug Display an
ontrol Equipment and	release the Orbiter fo	r its turnarous	d Operational
TASK LOCATION: MCF/KS	SC and WTR		
	Equipment Van		
MSK EQUIPMENT			
191	Workstands		
· · · · · · · · · · · · · · · · · · ·			
٠,			
<del></del>			
		<del></del>	
MANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS
	MECHANICAL TECH	5	M-HRS
	AVIONICS TECH	0	M-HRS M-HRS
	ENGINEERING	3	M-RKS M-HRS
	QUALITY CONTROL	0	M-HRS
	SAFETY	10	M-HRS
	OTHER		
INTERFACE REQUIREMENT	S:		

K OBJECTIVE: To remov	e DOD COMSEC FSE f	rom the Orbiter	cabin.	
			GOVGEO const	mant
SK PURPOSE: To init	late the turnaround	operations of	the COMSEC equi	men
nd release the Orbiter	for its turnaround	operations.		
ASK LOCATION: MCF/KSC	and WTR			
	Equipment Van			
	Workstands			
191	HOTASUARAS			
<u> </u>				
·				
	TOOL STON TECH	0	M-HRS	
MANPOWER REQUIREMENTS:	PROPULSION TECH _ MECHANICAL TECH _	1.5	M-HRS	
	AVIONICS TECH	1.5	M-HRS	
	ENGINEERING	0	M-HRS	
	QUALITY CONTROL	0.5	M-HRS	
	SAFETY	0	M-HRS	
	OTHER	2	M-HRS	
INTERFACE RECUIREMENTS	• - <u></u>			

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TASK OBJECTIVE:	To remo	ve the Tug Flight	Support Equip	ment from the	payload b
	<u> </u>				
	,				
			· · · · · · · · · · · · · · · · · · ·	of the Flight	Support
1104 10111000					
Equipment and	To remove the Tug Flight Support Equipment from the payload be the Orbiter Vehicle.  EK PURPOSE:  To initiate the turnaround operations of the Flight Support quipment and release the Orbiter for its turnaround operations.  EK LOCATION:  MCF/KSC and WTR  SK EQUIPMENT:  191 Workstands  134 Equipment Van  :  MPOWER REQUIREMENTS: PROPULSION TECH  AVIONICS TECH  5 M-HRS				
			,		
		•			
TASK LOCATION:	MCF/KS	C and WTR		·	
	191 W	orkstands			
INSK EQUIPMENT.					
	134 E	daibweic Awn			
			<u>;</u>		
				M UDC	
MANPOWER REQUIR	REMENTS:		- <del></del>	<del></del>	
				M-HRS	
			3	M-HRS	
		SAFETY	2	M-HRS	
		OTHER	19	M-HRS	
INTERFACE REOUI	REMENTS:	Operations must	be completed	prior to Shut	tle working
time of 26 ho	urs.				

ASK LOCATION:  MCF to PPF/KSC  ASK EQUIPMENT:  134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS:  PROPULSION TECH  AVIONICS TECH  AVIONICS TECH  QUALITY CONTROL  SAFETY  OTHER  6/10  LTC  CONTROL  SAFETY  OTHER  6/10  LTC  CONTROL  SAFETY  OTHER  6/10  LTC  CONTROL  SAFETY  OTHER  6/10  LTC  CONTROL  SAFETY  OTHER  6/10  LTC  CONTROL  CON	SK OBJECTIVE: Transfer	of Tug DOD Flight	upport Equipme	20 00 000 6270001
MANPOWER REQUIREMENTS: PROPULSION TECH O MECHANICAL TECH O MECHANI				
MANPOWER REQUIREMENTS: PROPULSION TECH O MECHANICAL TECHNOLOGY.	10000			
MANPOWER REQUIREMENTS: PROPULSION TECH 0 172 AVIONICS TECH 0 173 AVIONICS TECH 0 174 AVIONICS TECH 0 175 A				
MANPOWER REQUIREMENTS: PROPULSION TECH 0 172 MECHANICAL TECH 0 173 MINIONICS TECH 0 174 MINIONICS TECH 0 175 MINIO			and operations	on the 1/1 7 (a)+
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH	ASK PURPOSE:To all	ow required turnarou	ind operations	
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH 0 MECHANICAL TECH 0 MECH	Support Equipment			
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH				
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH 0 MECHANICAL TECH 0 MECH				
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH				
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH				
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH				
TASK EQUIPMENT: 134 Equipment Van  192 Security Vehicle  MANPOWER REQUIREMENTS: PROPULSION TECH				
MANPOWER REQUIREMENTS: PROPULSION TECH O MECHANICAL TECH O MECHANI	TASK LOCATION: MCF to	PPF/KSC		
MANPOWER REQUIREMENTS: PROPULSION TECH O MECHANICAL TECH O AVIONICS TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECH O MECHANICAL TECHNOLOGY.  INTERFACE REQUIREMENTS: Pequires airlock operation to mean airlock operation to mean airlock operation.	TASK FOUIPMENT: 134 Ed	luipment Van		
MANPOWER REQUIREMENTS: PROPULSION TECH O MECHANICAL TECH O MECHANI		ecurity Vehicle		
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  O  O  O  O  O  O  O  O  O  O  O  O  O				
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  O  O  O  O  O  O  O  O  O  O  O  O  O				
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  O  O  O  O  O  O  O  O  O  O  O  O  O				
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  O  O  O  O  O  O  O  O  O  O  O  O  O				
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  O  O  O  O  O  O  O  O  O  O  O  O  O				
MANPOWER REQUIREMENTS: PROPULSION TECH  MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  O  O  O  O  O  O  O  O  O  O  O  O  O				
MECHANICAL TECH 0  AVIONICS TECH 0  ENGINEERING 0  QUALITY CONTROL 1  SAFETY 0  OTHER 6/10  INTERFACE REQUIREMENTS: Pequires sirlock operation to interpretation to interpretation.	MANDONED DECUT PEMENTS .	PROPULSION TECH	0	TON.
ENGINEERING  QUALITY CONTROL  SAFETY  OTHER  OTHER  Dequires sirlock operation to increase to the same and th	PMNPOWER REQUIREMENTS.			W-1/2
QUALITY CONTROL  SAFETY  OTHER  OTHER  OPERATION  INTERFACE REQUIREMENTS:  Pequires sirlock operation to interface of the control of the cont		AVIONICS TECH	0	
SAFETY OTHER  OTHER  OFFICE REQUIREMENTS:  Pequires sirlock operation to have to the second of the s		ENGINEERING	0	
OTHER 6/10 -2  INTERFACE REQUIREMENTS: Pequires airlock operation to increase to the second s		QUALITY CONTROL	1	
INTERFACE REQUIREMENTS: Pequires airlock operation to have to the second		SAFETY		
		_		
	INTERFACE REQUIREMENTS	Requires airlock	operation t	o incres in on
olooplinees	cleanliness			
	LI FAMILI I II PSS			

er opertive. To trai	rse TO TPF (3.2.9)	quipment to the	rug Processing
acility			
ASK PURPOSE:To ini	tiate the ground turns	round operations	on the Flight
Support Equipment.	•		
	•		
		•	
ASK LOCATION: MCF of	r PPF to TPF/KSC		
TASK EQUIPMENT: 134	Four pment Van		
IASK EQUIPMENT:			
·			
			<del> </del>
			-
MANDOUED DECILI DEMENTS:	PROPULSION TECH	0	M-HRS
MANPOWER REQUIREMENTS:			M-HRS M-HRS
MANPOWER REQUIREMENTS:	PROPULSION TECH MECHANICAL TECH AVIONICS TECH		• • • • • • • • • • • • • • • • • • • •
MANPOWER REQUIREMENTS:	MECHANICAL TECH	0	M-HRS
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING	0	M-HRS M-HRS
MANPOWER REQUIREMENTS:	MECHANICAL TECH	0 0 0	M-HRS M-HRS M-HRS
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING QUALITY CONTROL	0 0 0 1	M-HRS M-HRS M-HRS M-HRS

SK OBJECTIVE: To trans	fer FSE to the Paylo	oad Processing	Facility
•			
To ini	tiate Tug vehicle FS	E turnaround o	perations
K PURPOSE: 10 1h1			
		<u> </u>	
ASK LOCATION: MCF-to-	-PPF/WTR		
DR EOGNIZON	ouipment Van		
DR EOGNIZON	quipment Van		
DR EUGHTEUM	quipment Van		
ASK EUGATIZATIO	quipment Van		
DR EUGHTEUM	quipment Van		
SK EUGHTON	quipment Van		
DR EUGHT	quipment Van		
DR EOGNIZON	quipment Van		
ASK EQUIPMENT: 134 E		0	M-HRS
DR EUGHT	PROPULSION TECH	0	M-HRS M-HRS
ASK EQUIPMENT: 134 E	PROPULSION TECH		<del></del>
SK EQUIPMENT: 134 E	PROPULSION TECH	0	M-HRS
SK EQUIPMENT: 134 E	PROPULSION TECH	0 0	M-HRS M-HRS
ASK EQUIPMENT: 134 E	PROPULSION TECH	0 0 0	M-HRS M-HRS M-HRS

	SFER TUG AND SPACECRAFT T		
ASK OBJECTIVE: Tr	ansfer the returning DOD	payload to the	payload processing
facility at KSC			
	allow the returning DOD	nevload to begi	n demating and mai
W3K LOW OGE	المراجع والمناطق والمجارة والمراجع والمناطق والم		
tenance and refurb	ishment operations and to	release the MA	SA TUE TOT 111
operations.			
TASK LOCATION: P	PF/KSC		
TASK EQUIPMENT: 1	83 Transporter		
182 T	ractor		
123 T	ug Cover		
122 S	pacecraft Cover		
-	ecurity Vehicle		<del></del>
192 <u>s</u>	ecurity venicie		
_			
124 0	radles		
MANPOWER REQUIREME	NTS: PROPULSION TECH	0	M-HRS
	MECHANICAL TECH	2	M-HRS
	AVIONICS TECH	0	M-HRS
	ENGINEERING	2	M-HRS
	QUALITY CONTROL	0	M-HRS
	SAFETY	00	M-HRS
	OTHER	10/14	M-HRS
INTERFACE REQUIREN	MENTS:		

SK OBJECTIVE: To	separa	te the returning	Tug and	spacecra	ift.
K OBJECTIVE:				-	
·					
SK PURPOSE: To	allow	recycle operatio	ns to be	gin on th	e Tug and the
pacecraft.					
				· · · · · · · · · · · · · · · · · · ·	
		<del></del>			
K LOCATION: T	PF/KSC	and PPF/WTR			
SK EQUIPMENT: 1	91 Wo	rkstands		<del> </del>	
	verhea	d Crane			
-		aft Slings			
	paceci	art orres			·
183 <u>T</u>	ranspo	rter			
124 0	radles				
-					
ANPOWER REQUIREM	FNTS ·	PROPULSION TECH		0	M-HRS
MAPUNER REQUIREM		MECHANICAL TECH		3	M-HRS
		AVIONICS TECH		3	M-HRS
		ENGINEERING		1	M-HRS
		QUALITY CONTROL		0	M-HRS
		SAFETY		1	M-HRS
		OTHER		4	M-HRS

ASK TITLE:		rug to TPF (3.3.3)		<del></del>	
ASK OBJECTIVE: To	tran	sfer the returning	Tug to the Ti	g Processing Fa	cility
		· · · · · · · · · · · · · · · · · · ·			
	,		<del></del>		
				the flux train	1070
ASK PURPOSE: To	allow	the recycle operat	ions to begi	n on the lug ver	i cre.
			, ·		
	<u> </u>				
TASK LOCATION:	(SC				
TASK EQUIPMENT:	183 T	ransporter			
182	Tracto	•			
		ver			
<del>-</del>					
<b>ا</b>		ad Crane			
**************************************	•.				
124	Cradle	s			
•			·		
	CNTC	PROPULSION TECH	0	M-HRS	
MANPOWER REQUIREM	Fu12:	MECHANICAL TECH		M-HRS	
		AVIONICS TECH	0	M-HRS	
		ENGINEERING	4	M-HRS	
		QUALITY CONTROL	0	M-HRS	
		SAFETY	0	M-HRS	•
		OTHER	13	M-HRS	
INTERFACE REQUIRE	WFN12:	•			

ASK TITLE:		DOD page	QUIPMENT (	raft equipme	ent on a delivery
SK OBJECTIVE: To	recov	er DOD pecul	lar spacec	Coro odraba	ent on a delivery
ission.					
	o remor	re DOD spaced	craft equip	ment to "de	classify" the Tug
wehicle prior to	recycle	e obelacions	111		
				<del></del>	
			<del>, , , , , , , , , , , , , , , , , , , </del>	•	
TASK LOCATION: _	PPF/KSC	; 			
TASK EQUIPMENT:	183 Tr	ransporter			
	Work St	tands			
	Overhe	ad Crane			
123	Tug Co	vers			
124	Cradle	8			
					<del></del>
					,
MANDOUED DECITOE	MENTS .	PROPULSION	TECH	0	M-HRS
MANPOWER REQUIRE	LIFI4 1 9 +	MECHANICAL		5	M-HRS
		AVIONICS TE	<del></del>	11	M-HRS
		ENGINEERING		0.5	M-HRS
		QUALITY CON	ITROL	3	M-HRS
		SAFETY	1.	00	M-HRS
		OTHER		8	M-HRS
INTERFACE REQUIF	CUPNTS.	•		•	

MAL 1916	ER TUG TO PPF (3.3.5)		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
SK OBJECTIVE: Transfe	er Tug to the DOD Payl	oad Processing	Facility
er Bubbace. For DO	D Payload Peculiar Equ	ipment removal	at KSC to
itiate turnaround op	erations of the Tug at		
		· .	
ASK LOCATION: MCF-to	o-PPF/KSC		
	Transporter		
182 Tract			
	over		
124 <u>Crad</u>	Les		
192 <u>Secu</u>	rity Vehicle		
` • •			
ANPOWER REQUIREMENTS:	PROPULSION TECH	0	M-HRS
•	MECHANICAL TECH	2	M-HRS
	AVIONICS TECH	0	_ M-HRS
	ENGINEERING	<u>2</u> 	M-HRS
	QUALITY CONTROL	0	M-HRS
	OTHER	10/14	M-HRS

SK OBJECTIVE: _1	ransfer	the returning ]	payload	to the Tu	g processing	14011110,1
		the returning	navload	to begin	demating and	maintenan
nd refurbishmen	t operat	ions.				
						·
ASK LOCATION:	KSC					
ASK EQUIPMENT:	183 1	ransporter				
182	Tractor	•				
123	Tug Con		. •			
122	Spacec	raft Cover				
124	Cradle	3				
	Overhe	ad Crane				
		PROPULSION TEC	u	0	M-HRS	
MANPOWER REQUIR	FWEU12:	MECHANICAL TEC		3	M-HRS	
		AVIONICS TECH		0	M-HRS	
		ENGINEERING		4	M-HRS	
		QUALITY CONTRO	L	0	M-HRS	
		SAFETY		0	M-HRS	
		OTHER		13/17	M-HRS	
INTERFACE REQUI	REMENTS		•			

.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		JG AND SPACECRAFT (			ecraft
PK OBSECTIAE:	10 000		,		
·					
ASK PURPOSE: _	To all	ow recycle operation	ons to	begin on th	e Tug and th
spacecraft.					
1.					
			<u> </u>	<u> </u>	
TASK LOCATION:	Payloa	d Processing Facil	ity/KS	C	
TASK EQUIPMENT:	191 W	orkstands	124	Cradles	
	Overhe	ad Crane	140	Handling Ki	t
	Spaced	raft Slings			
183		porter			
103					<u></u>
	Airloc				<u></u>
123	Tug Co	overs			
122	Spaceo	raft Cover		<del> </del>	<del></del>
MANPOWER REQUIRE	MENTS:	PROPULSION TECH _	· 	0	M-HRS
		MECHANICAL TECH _		<u> </u>	M-HRS
		AVIONICS TECH _	·	1.5	M-HRS
		ENGINEERING _		1.5	M-HRS
		QUALITY CONTROL _		1.5	M-HRS
		SAFETY _		3	_ M-HRS
		OTHER _	· · · · · ·	10.5	M-HRS
INTERFACE REQUIR	EMENTS .				

	er spacecraft peculi	(3.3.8) ar equipment for	llowing a deli	very
SK OBJECTIVE: To recov	er spacecraft pecuar-			
lssion.				•
SK PURPOSE:To remov	ve special spacecraft	equipment from	the Tug prior	to
ecycle operations in t	•			
ecycle operations in the				
			•	
TASK LOCATION: PPF/WIT	R and TPF/KSC			
TASK EQUIPMENT: 183 T	ransporter			
<b></b>				
191 Side W	ork Stands			
124 Cradle	28		<del></del>	
· · ·				
		:		
	DDODIN STON TECH	0		
MANPOWER REQUIREMENTS:	PROPULSION TECH	0		
MANPOWER REQUIREMENTS:	MECHANICAL TECH	1.5		
MANPOWER REQUIREMENTS:			M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH	1.5 0.5/2.5	M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH AVIONICS TECH ENGINEERING	1.5 0.5/2.5 0	M-HRS M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL	1.5 0.5/2.5 0	M-HRS M-HRS M-HRS M-HRS	
MANPOWER REQUIREMENTS:	MECHANICAL TECH  AVIONICS TECH  ENGINEERING  QUALITY CONTROL  SAFETY  OTHER	1.5 0.5/2.5 0 0 0	M-HRS M-HRS M-HRS M-HRS M-HRS M-HRS	

	R TUG TO PPF (3.3.9) ransfer the returning T	hig to the Pavl	oad Processing
SK OBJECTIVE: To t	ranster the returning i	ug to the ray	.oau 110ccoolag
acility			<u></u>
ASK PURPOSE: To a	llow the recycle operat	ions to begin	on the Tug vehicl
	·		
		·	
		· · · · · · · · · · · · · · · · · · ·	
ASK LOCATION: WTR			
ASK EQUIPMENT: 183	Transporter		<del></del>
182 Trac	tor		
133 Tug	Covers		
Ove	rhead Crane		
Air	Lock		
124 Cra	dles		
ANPOWER REQUIREMENT	S: PROPULSION TECH	0	M-HRS
MAPONER REQUIREMENT	MECHANICAL TECH	3	M-HRS
	AVIONICS TECH	0	M-HRS
	ENGINEERING	Įţ.	M-HRS
	QUALITY CONTROL	C	M-HRS
	SAFETY	0	M-HRS
	OTHER	13/17	M-HRS
NTERFACE REQUIREMEN	rs:		
minume nedasire en		<del></del>	•

ASK TITLE:	TRANSFER	TUG AND	SPACE	CRAFT TO	FFF	(3.3.	107		
ASK OBJECTIVE:	Transfer	the ret	urning	Payload	to t	he Pa	yload	Processi	ng Facili
							· · · · · · · · · · · · · · · · · · ·		
ASK PURPOSE:	To allow	the ret	urning	payload	to b	egin	demat	ing and m	aintenanc
and refurbishme	nt operat	ions.		<u>., </u>		<del></del>		·	
· .									······································
	1 /								
		·			· ,				
ASK LOCATION:	WTR	·		<del></del>			<u> </u>		
TASK EQUIPMENT:	183 T	ransporte	r						
182	Tractor		<del></del>						
123	3 Tug Cov	rer						<del></del>	
122	2 Spaceci	aft Cove	r						
		ad Crane							
	Airloc	k							
12	Cradle	s					المستنساء معر		
MANPOWER REQUII	REMENTS:	PROPULS	ION TE	СН	0			M-HRS	
				CH				M-HRS	
		AVIONIC	S TECH		0			M-HRS	
		ENGINEE	RING		14			M-HRS	
		QUALITY	CONTR	OL	0			M-HRS	
		SAFETY			0			M-HRS	
		OTHER		·	13/	17		M-HRS	
INTERFACE REQU	IREMENTS:								

#### TASK TIMELINES

FOR

#### THE CRYOGENIC TUG

#### GROUND AND LAUNCH OPERATIONS

13 JULY 1973

NOTE: The timelines enclosed utilized the following skill breakdown notation as furnished by NASA:

- a. Propulsion Technicians
- b. Mechanical/Structural/Thermal Technicians
- c. Avionics Technicians
- d. Engineering
- e. Quality Control
- f. Safety
- g. Other

	•					ANNI	MANNING REQUIREMENTS	ing-		SI	1		ç		
			3	QUANTITY	늰						¥	MAN-HOURS	SE		
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Prepare Preliminary M & R Schedule	0	0	0	М	н	н	0		0	0	0	16	m	m	0
Analyze T/M for Unscheduled M & R	0	0	0	m.	Н	Н			0	0	0	18	9	9	
	0	0	0	m	Н	Н	0		0	0	0	77	#	<b>4</b>	0
18 m de 18 m	0	m	0	0	0	N	т		0	m	0	0	0	m	1.5
Prepare for Inspection & C/0	0	9	0	0	0	0	0		0	22.5	0	0	0	0	0
Perform Post Flight/Receiving Inspection	m	m	N	m	8	0	0		ηΖ	4ς	80	50	16	0	0
1.1.7.1 Post Flight Checkout - Main Propulsion Pressurization-Ambient Helium & GH2 Bleed	N	0	н	н	н	0	0		16	0	<b>ω</b>	60	<b></b>	0	<u> </u>
1.1.7.2 Post Flight Checkout - Main Propulsion Pressurization - Cold Helium & GH2 Bleed	O.	0	H	н	н .	0	0		17	0	8.5	8.5	8.5	0	0
1.1.7.3 Post Flight Checkout - Main Propulsion Pressurization - Autogenous (All engine Bleed)	N	0	H	н	н	0	0		17	0	8.5	8.5	8.5	0	• 
1.1.7.4 Post Flight Checkout - Main Propulsion Zero NPSH	N	0	н	н	H	0	0		16	0	æ	Φ		0	0
1.1.7.5 Post Flight Checkout - APS Subsystem Monopropellant - Blowdown	0	0	4	Н	н	0	0		ā.	0	-	-	<u> </u>	<u> </u>	
•	•														

			QUAN	QUANTITY		•				MAN	NAN-HOURS	ည္ဆု			
	<b>—</b>	<del>—</del>	ບ	<u>-</u>	<u>—</u>			<u> </u>	e -	ن د	Δ_	ы	<u></u>		
1.1.8.9 Perform Post-Storage C/O - Avionics	0	0	~	8	<u></u>	•		<u> </u>	<u> </u>	327	99.5	10	0	0	
1.1.9.1 New Tug Checkout - Main Propulsion Pressurization = Ambient Helium & GH <sub>2</sub> Bleed	N	0	н	· H	<b>A</b>	0	0	09	· · · · · · · · · · · · · · · · · · ·	30	30	30	0	0	4.4
1.1.9.2 New Tug Checkout - Main Propulsion Pressurization = Cold Helium & GH2 Bleed	N	0					0		0	₹	₹€	₹€	Ó.	0	
1.1.9.3 New Tug Checkout - Main Propulsion Pressurization = Autogenous (All Engine Bleed)	N	0	<b>-</b>			0	0	75	0	27	27	27	0	0	
1.1.9.4 New Tug Checkout - Main Propulsion Zero NPSH	a	0	-	<del></del>	<del></del>	0	0	52	0	92	26	56	0	0	
1.1.9.5 New Tug Checkout - Aps Subsystem Monopropellant - Blowdown	N	0	<u>-</u>	<del></del>		0	0	22	0	#	רנ	Ħ	0	0	
1.1.9.6 New Tug Checkout - APS Subsystem Monopropellant - Pressurized	N	0	н	н	<u>-</u>	0	0	98	0	18	18	18	0	0	
1.1.9.7 New Tug Checkout - APS Subsystem Bi-propellant	N	0		Н		0	0	20	0	- 25	25	25	0	0	
1.1.9.8 New Tug Checkout - APS Subsystem Cryogenic	Ø	0	rd	٦		0	0	₹8	0	7,7	2	715	0	0	
1.1.9.9 New Tug Checkout - Avionics	0	0	~	N	<u>н</u>	0	0		<del>-</del>	0 48.5	69	10	0	0	
1.1.10 Prepare/Update M & R Schedule	0	0	0	ю	٦	н	0		•	0	77.	<i>=</i>	#	0	
1.1.11 Perform Structure/Mech. M & R	0	6.8	0	0	0	0	0		0 17	°	<u> </u>	0	0	0	
1.1.12 Perform Propulsion M & R	2.3	0	0	0	0	0	0	<b>7</b>		- O	<u> </u>	0	0	0	
1.1.13 Perform Avionics M & R	0	0	<i>=</i>	0	0	0	0		<del>-</del>	8	0	0	0	0	
	-	•	-	•	•	•	•	•							

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				<b>∀</b>	m m	<u> </u>	Ω	EI .	<u> </u>	<u> </u>	<u> </u>	<b>m</b>	<u> </u>	Α	<u>—</u>			
	•	1.1.14 Remove M & R GSE		0	-=	0	0		0	0	•	<i>-</i>	0	0	r.	0	0	
. •		1.1.15 Receive FSE at TPF/PPF	/PPF	Ö	m	0	0	0	0	κ'n	•	<u></u>	0	0	0	0	<u>m</u>	
		1.1.16 Prepare For Inspection	tion	0	4	0	0	0	0	0		16	0	0	0	0	0	
		1.1.17 Perform FSE Post Flight/Receiving	light/Receiving Insp.	Q	<b>4</b>	က	0	N	0	•	ج 	4 11.5	12	0	16	0	0	
		1.1.18 Prepare/Update M & R Schedul	R Schedule	0	0	0	m	П	-	0	<u> </u>	<u> </u>	0	8.5	1.5	.5	0	
		1.1.19 Perform FSE M & R		CV	ч	н	0	0	0	0	<u></u> 왔	91	91	0	0	0	0	
		1.1.20 Prepare for Storage	<b>U</b>	N	4	N	0	0	0	•	9	₹	8	0	0	0	0	
1		1.1.21 Prepare for Transport	ort	0	-#	0	0	0	0	. 04	0	<u>~</u>	0	0.	0	0	н	
<b>&gt;</b> - <i>i</i>		1.1.22 Transfer to Storage	<b>v</b>	0	N	0	0	0	0	N	• 	_ <del></del>	0	0	0	0	_ <del></del>	
133		1.1.23 Perform Storage Support	pport	Н	-	н	0	ч	0	0	<i>=</i>	਼ੜ <del>-</del>	<i>=</i>	0	#	0	0	
3		1.1.24 Remove From Storage	9	н	Н	٦	0	ч	0	0	<del></del> -	<b>4</b>	*	0	#	0	0	
		1.1.25 Transfer to TPF/PPF for M &	F for M & R	0	N	0	0	0	0	0		. 60	0	0	0	0	0	
e .		1.1.26 Transfer to Prelaunch	nch	0	0	0	0	0	0	~		<i>a</i>	0	0	0	0	<b>a</b>	
	1.2	POST MAINTENANCE CHECKOUP									<del></del>							
		1.2.1 Post M & R Verification	stion	н		Н	0	ю	0	•		<u>п</u>	Н	0	#	0	0	
		1.2.2 Perform Post M & R Verificat	Verification - FSE	н	٦	7	0	Э	0	0		2	S	0	80	0	0	
	2.1	TUG SYSTEM & INTEGRATED SYSTEM CHECKOUT	STEM CHECKOUT	-,-,					-,,- <del></del>							<del></del>	<del></del>	
		2.1.1 Receive FSE from M &	cc	0	0	0	0	Н	н	~		0	0	0	0	N	<del>_</del> =	
		2.1.2 Receive Tug from M	les •8	0	0	0	0	0	0	4		0	0	0	0	0	7.	
			-		_	-		-		_	-	_	_	-	-	-	-	

		13	6	0	0 0		9	М	4	0	80	80	m	m	<b>1</b>	Į.	15	M
	<u> </u>	0	0	0	17 23		0	0	0	0	0	N	н	0	н	,	0	0
ဖွာ	M	0	N	0	18		н	N	N.	.0	N	N.	н	0	<b>~</b>		m.	ਜ
MALY-HOURS	Α	0	0	N	34		0	0	0	8.5	0	0	0	77	N		0	0
MA	_ ပ	0	0	0	10		Н	#	N	15	N	.#	#	23	0		0	9
	<b>—</b>	0	0	7	10	·	н	#	N	0	2	80	4	ပ	70		0	\$
	<b>-</b>	0	0	0	140 88		0	0	0	0	0	#	0	0	0		0	0
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OUA OUA	ບ	0	0	0	<b>д</b> н		H	8	. H	m	α.	CV	N	m	0		0	0
	æ	0	0	ч	2 2		-	2	H	0	N	<b>4</b>	α	0	2		0	0
	4	0	0	0	# #		0	0	0	0	0	8	0	0	0		0	0
		2.1.3 Frepare Tug for PPF Transfer	2.1.4 Transfer Tug to PPF		2.1.6a Deleted 2.1.6b Deleted 2.1.7 ACPS Loading (Mono) 2.1.8 ACPS Loading (Biprop)	A	2.2.1.1 Prepare for Spacecraft Equipment	2.2.1.2a Install Spacecraft Equipment	2.2.1.2b Install Spacecraft Equipment	2.2.1.3 Verify Tug-To-Spacecraft Equipment Interfaces	2.2.2.a Prepare Tug for Spacecraft	2.2.2.b Prepare Tug for Spacecraft	2.2.3 Mate Tug and Spacecraft	2.2.4 Verify Tug-To-Spacecraft Interfaces	2.2.5 Verify Cleanliness	2.3 SHUTTLE/TUG MATE	2.3.1 Transfer FSE to MCF	2.3.2.1a (Console) Install FSE in Cabin
						ิณ										N		

				$\sim$		QUAN	QUANTITY				,		MAN	MAN-HOURS	တ]		
				⋖	m	υ	<u> </u>	<u> </u>	<u> </u>		<u>«</u>	m	<u>ပ</u>	Α	<u> </u>	<u> </u>	
	8.3	.2.1b	2.3.2.1b (Comsec) Install FSE in Cabin	0	٦	٦	-	<u></u>	0		<u> </u>	1.5	3.5	-	~	0	•
	~	3.2.2	2.3.2.2 Install FSE in Payload Bay	~	<b>a</b>		8	8		~		<u>.</u>	2	<i>a</i>	<i>a</i>	н	77.
	~	2.3.3	Verify FSE Interfaces	0	0	m	0		•		<u> </u>	°	m	0	-	0	.a
	જં	2.3.4	Transfer Payload to MCF	0	0	0	0	0	•	~	<u> </u>	°	0	0	0	0	m
	તં	2.3.6	Payload Installation Preps	Н	~~	٦	N	0	•		<u></u>	~	н	N	0	0	19
	જાં	2.3.7	Payload Installation MCF	Н	<u>ر</u>	н	н	0	Н	<u> </u>	~~	8त	N	N	0	a	т
	જાં	2.3.9	Verify Payload-To-Shuttle Interfaces	m	<u>н</u> ,	O.		~	•	~	27	- Φ	18	36	18	0	8
2.4		COUNTDOWN							<del></del>	<del></del>							<del></del>
	ď	2.4.1	Orbiter/Payload Integrated System Test	Ø	<b></b>	N	<b>.</b>	<u>~</u>		8	∞	36	18	30	72	4	8
	a	2.4.1a	Monitor Storable ACPS	٦	0	0	0	0	<del></del>	•	₹8	<u> </u>	0	0	0	-ಪ	0
	8	2.4.2a	Tug Service at Pad	m	<sup>Q</sup>	<u>~</u>		OI.	<del></del>	0	. <del></del>	~	9	9	2.5	۲.	0
	જં	2.4.2b	Tug Service at Pad (Non-Cryo)	m	<b>4</b>	#	N	٦		•		8 13	13	9	ю	m	0
	ď	2.4.3	Tug Service at Pad (Cryo's)	Ŋ		<b>4</b>	_ <del></del>	m	<del></del> -	2	10	91	16	80	9	N	9
	ั้ง	2. h.3a	Tug Service at Pad (Cryo's)	a	0	N	<b>4</b>	0.	0	~		0	m	9	0	0	т
	o.	2.4.3b	Tug Service at Pad (Cryo's)	8	0	Н	4	0	•	•		°	CV .	9	0	0	0
	તં	2.4.2	Final Checks at Pad	0	0	0	~	•	•	•		<u> </u>	0	154	0	0	0
	<b>તં</b>	2.4.5	Remove Payload (Pad)	~	~	a	, CV	н		-		10	<i>a</i>	4	6	m	23
	ai	2.4.6	Payload Installation or Removal Preps (Pad)	<b>ત</b>	Н	<u>-</u>	<u></u>	0	0	<b>4</b>	0.5	5 0.5	0.5	0.5	6	0	N
				_	_	-	-	-	-			-	_	_			

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	4	<b>A</b> .	ပ	A	ы	<u> </u>	<del></del>			<b>m</b>	<u>a</u>		<u> </u>	<u> </u>		
2.4.7 Payload Installation (Pad)	ч	~	H	H	0	٦	~		8	15	N ·	~	•	8	~	
2.4.8 Transfer Payload to Pad	0	<b>ͺ</b> Ο	0	N	0	0	9		0		0	#	0	0	72	
. SAFE AND SECURE											<del></del>					
3.1.1 Tug Ground Safing at Safing Area	0	0.	a	м		<u>ط</u>	<b>a</b> ,		0	0	80	9	8	80	20	
3.1.1.a Tug Ground Safing at Safing Area	0	0	N	်က	-	· ~	<b>4</b>		0	0	12 1	10	01	10	20	
3.1.2 Transfer Tug to SPF	0	н	0	-	0	0	9		0	-	0	α	0	0	0	
3.1.3.a Tug ACPS Safing	8	2	e,	<b>-</b>	٦.	~	0		91	35	2 24	25	ี ส	σο	Ò	
3.1.3.b Tug ACPS Safing	8	9	м	<del></del>	N		0		27		15   1	16	10	Ь	0	
3.1.4 Transfer Tug and S/C to SPF 3.1.5a Deleted	0	Н	0	<u></u>	0	0	9	<del></del>	0	н	0	N .	0	0	12	
	<b>=</b>	4	Ч	0	٦		٦		56	16	·5 <u> </u>			9	ਜ	
3.1.7 ACPS Safing (BiProp) SHUTTLE/TUG DEMATE	4	<i>a</i>	н	Q.	Н	<b>-</b>	Н		36	 ₹			<u>:</u> -	<del></del>	2	
3.2.3 Recover Tug at MCF	0	2	0	-	0	7	9		0	10	0	9	0	8	23	
3.2.5 Recover Tug and S/C at MCF	0	~	0	٦	0		9		0	15	0	9	0	~	772	
3.2.6.a Recover FSE (Cabin) Equipment (Console)	0	Q	н	0	٦	. 0	<b></b>		0.	2	~	•	m	0	07	
3.2.6.b Recover FSE (Cabin) Equipment (COMSEC)	0		<u>~</u>	0	~	0	~		0	1.5	1.5	<u> </u>	0.5	0	N	
3.2.7 Recover FSE (Payload Bay) Equipment	7	4	<b>-</b>	~	2	<u>~</u>	9		Н	ī	2	<u>س</u>	m	~	19	
3.2.8 Transfer FSE to PPF	0	0	0	0	-	0	<b></b>		0	0	0	•	<u></u>	0	9	
2.9 Transfer FSE to TPF	0	0	0	0	н	0	<u>-</u>		0	0	0	0	-	0	10	
3.2.10 Transfer FSE to Par (	~	0	0	0		0	<u>-</u>		0	0	0	•	٦	c	10	

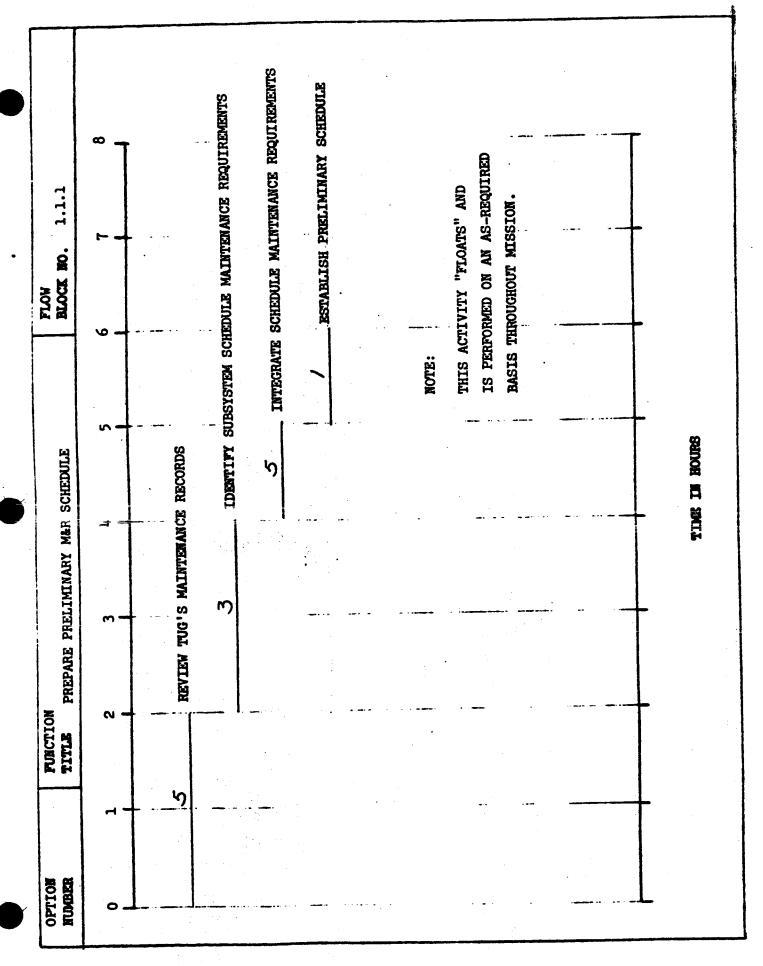
. MAN-HOURS	F G A B C D E F G	0 5 0 2 0 2 0 0 10	1 4 0 3 3 1 0 1	0 0 7 0 8 0	0 4 0 2 10.5 3 0	0 5 0 2 0 2 0	0 2 0 1 0 0 0	1 4 0 4 1.5 1.5 1.5 3 10	0 3 0 1 0.5 0 0 0	0 0 17 0 8 0 9 0	0 2 0 1 0 0		2 2 70 22 22	2 4 54 42 106 32 20	2 4 16 35 42 22 21 15	24 15 16 10	1 6 0 10 0 6 0 2	1 6 0 15 0 6 0 2
OUANTITY	BCDE	1 0 1 0	2 2 1 0	1 0 1	2 1 1 1	1 0 1 0	1 0 1	3 1 1	2 1 0	1 0 1 0	1 0 1 0		2 2 7	E 3	5 3 4 5	6 3 4 2	5 0 1 0	0 0 9
	SPACECRAFT/TUG DEMATE	Transfer Tug and S/C to PPF	Demate Tug and Spacecraft	Transfer Tug to TPF 0	Recover Spacecraft Equipment	Transfer Tug to PPF	Transfer Tug and Spacecraft to TPF 0	3.3.7 Demate Tug and Spacecraft 0	Recover Spacecraft Equipment	Transfer Tug to PPF	Transfer Tug and Spacecraft to PPF 0	ALTERNATE TIMELINES	2.1.6.a Storable Propellant Servicing	b Storable Propellant Servicing	a Twg ACPS Safing	b Tug ACPS Safing	Recover Tug at Safing Area	Recover Tug and Spacecraft at Safing Area
	ပ္ထ	3.3.1	3.3.2	3.3.3	3.3.4	3.3.5	3.3.6	<u></u>	3.3.8	3.3.9	3.3.10		6	2.1.6.b	3.1.3.8	3.1.3.b	3.2.2	۳. دو. دو.

BASELINE TIMELINES

FOR THE

MDAC

CRYOGENIC TUG GROUND OPERATIONS



1.1.2	77 77		ULTY LRU	EQUIREMENTS	HROUGHOUT	
BLOCK NO.	18	i IER RUN	4 ANOMALIES TO FA	DEFINE UNSCHEDULED MAR REQUIREMENTS	THIS TASK "FLOATS" AND IS PERFORMED ON AS-REQUIRED BASIS THROUGHOUT MISSION.	
DULE MER	15	PROCESS I/M DATA THROUGH COMPUTER RUN	IDENTIFY SUBSYSTEM ANOMALIES TO FAULTY LRU	DEFINE C	NOTE: THI AND AS-	
E T/M FOR UNSCHEDULE MAR	9 12 	PROCESS T/M DA	מ			
TITLE ANALYZE TA	9 -					
NUMBER	0 3					

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3	<b>®</b> 7	SDULK SDULK	
FLOW 1.1.3 BLOCK NO.	2 9	UPDATE MAR SCHEDULE	
	~	INTEGRATE SCHEDULED AND UNSCHEDULED MAR REQUIREMENTS  UPDATE MAR SCHEDULE	
E MAR SCHEDULE	e		
FUNCTION UPDATE MAR	2 -	<u>'</u>	
OPTION	0 _		

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3 POSÍTION TUC (ON TRANSPORTER) AND ESTABLISH AND VERIET ELECTRICAL GROUND  A PRINCIP PROTECTIVE COVERS  A PRINCIP RANCH SAFETY CHECK  THE IN BOURS	OPTION NUMBER	FUNCTION	RECEIVE	TUG AT TPF/PPF	PF		FLOW BLOCK NO.	1.1.4	
POSITION TUG (ON TRANSPORTER)  3 REMOVE PROTECTIVE C  2 PERFORM SAFET	0 _				5		<b>\</b> \$	7 8	•
COVERS	ю	POSITION TUG (0	N TRANSPORTER	_	ISH AND VERIF	Y ELECTRICA	AL GROUND		
PERFORM SAFETY CHEC		S REWO	VE PROTECTIVE		· · · · · · · · · · · · · · · · · · ·				
SECTION IT BOURS		7							
TIME IN HOURS									
			·	TDG	E IN HOURS				

	•								
1.1.5	80		<b></b>			MD POWER AND			• .
PLOW BLOCK NO.	2 2		•	IN CONFINED AREAS	RIER	POSITION/CONNECT REQUIRED GSE AND GROUND POWER AND PERFORM SELF CHECK			
0	5 6			(BREATHABLE AIR) IN CO	REMOVE FORWARD SKIRT METEOROID BARRIER	ONNECT REQUIR			·
FOR INSPECTION AND C/O	~ <b>~</b>	•	•••		PORWARD SKIRT	POSITION/C	•	. <u>-</u>	TIKE IN HOURS
	- 3		ACCESS PANELS/DOORS	IR CONDITIONING	REMOVE	4	The second second of the second secon	. <b>.</b>	<u>.</u>
N PREPARE	2			INSTALL AIR	A				-
TITLE	1	POSITION WORKSTANDS	-Sol	m)					-
OPTION	0 -	6 POST			. <del></del>			. , <del></del>	·

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	,							
9.	16							
1.1.6	14	BSYSTEM			ro			
FLOW BLOCK BO		INSPECT STRUCTURES/MECHANICAL SUBSYSTEM	(STEM	STEM	DOCUMENT SUBSYSTEM DISCREPANCIES			
NOI	12	ES/MECH	INSPECT PROPULSION SUBSYSTEM	INSPECT AVIONICS SUBSYSTEM	rem disci	•		
POST FLIGHT RECEIVING INSPECTION	10	STRUCTUE	PROPULS	r AVIONIC	i Subsyst	• .	΄	
ECEIVING		inspect	INSPECT	INSPECT	DOCUMENT		TIME IN HOURS	
FLIGHT R	<b>&amp;</b> -						E STATE OF THE STA	
	9_			N				
PERFORM								
FUNCTION TITLE	·	4			7			
EH	~ ·		_	<del></del>				
× #								
OPTION	0 -				}			

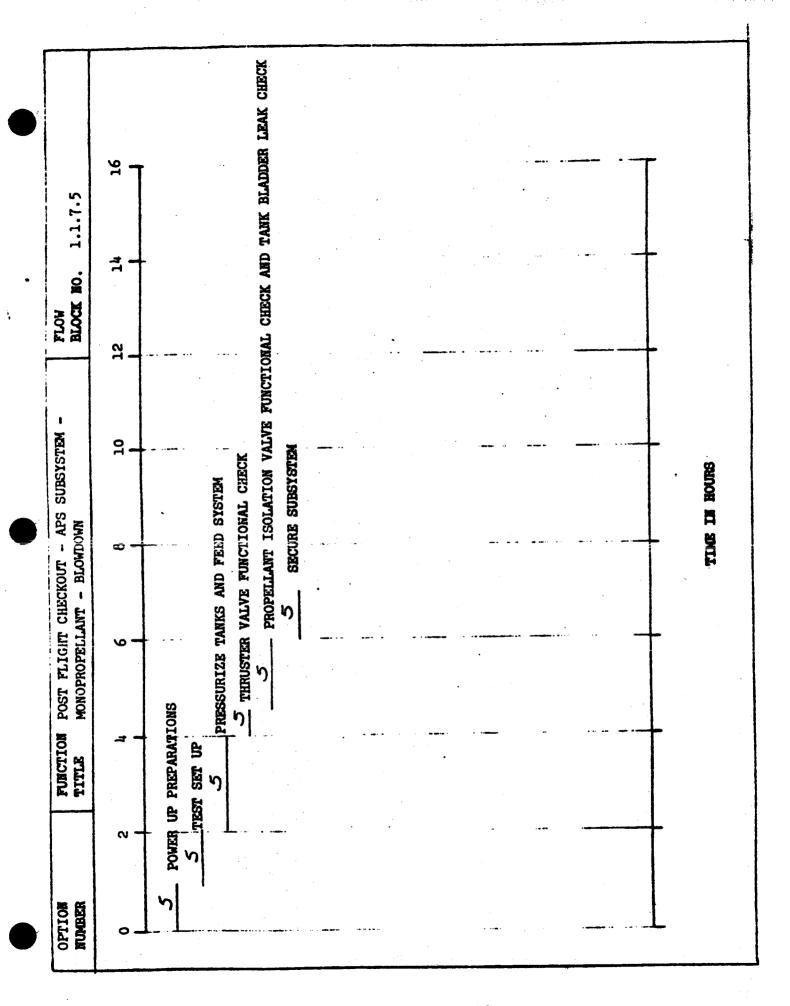
													٠							
1.1.7.1	16	•	- ••																	
FLOW BLOCK NO.	12 21			• •			•			•		•••			• ·	•			-	
OHLSION GH <sub>2</sub> BLEED	10 01			I VALVES	LATION VALVES		ENGINE FUNCTIONAL CHECK	SECURE : SUBSYSTEM											<del>-</del>	<b>9</b> 2
- MAIN PRO	∞ -		•	EXTERNAL LEAK CHECK TO ISOLATION VALVES	INTERNAL LEAK CHECK OF ISOLATION VALVES	RGES	ENGINE FUNC	SEG		•	•		. <b>-</b>		• ••••	•			<del>-</del>	TIME IN HOURS
POST FLIGHT CHECKOUT .	9-		TZATTON	RNAL LEAK CHEC	INTERNAL LEA	S VERIFY PURGES	7)	•			- ·· <del></del> -	•		-		<del>-</del>			-	
FUNCTION POST FLIGHT	<b></b>	POWER UP PREPARATIONS	TEST SET UP	S EXTE	5	<i>.</i> *		•	. up - san =			•			<del></del>	•				
E #	2-	POWER UP	TEST S			-									<b>.</b>	-		_ ·. · · · · · · · · · · · · · · · · · ·		
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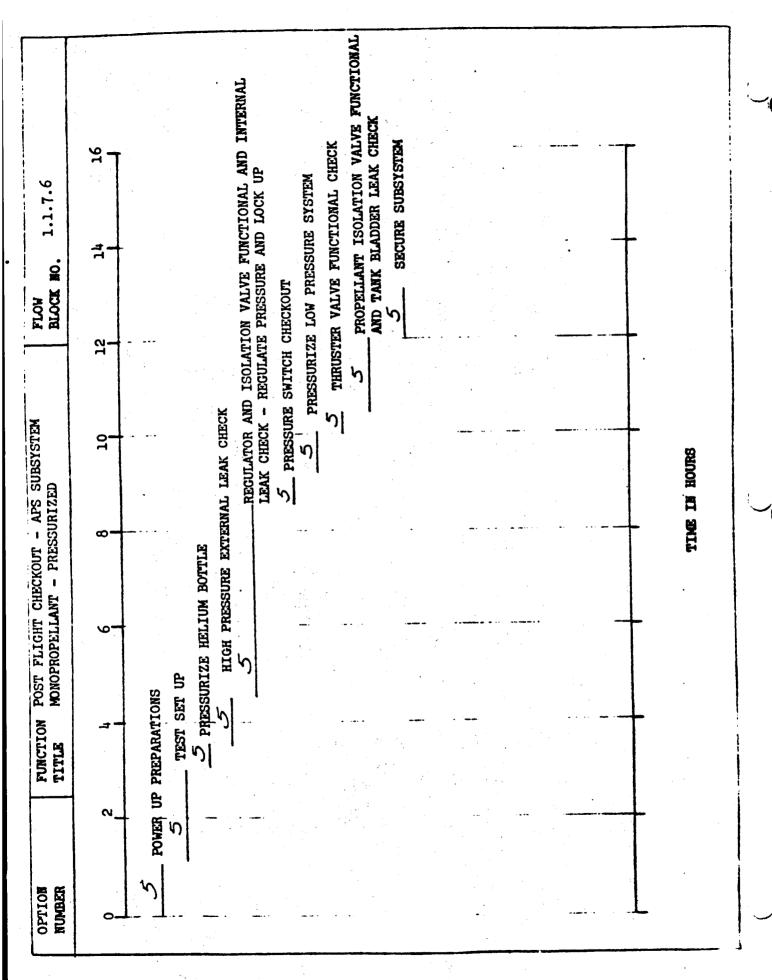
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FLOW	BLOCK NO.	4 <u>r</u>	-						,				•			_				
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- MAIN PROPULSION					CHECK TO ISOLATION VALVES	INTERNAL LEAK CHECK OF ISOLATION VALVES		ENGINE FUNCTIONAL CHECK	SECURE SUBSYSTEM										•	TOR II BOUR
CHECKOLIT	1	6 8				RNAL LEAK CHI	ERIFY PURCES	S. EN			-	• • <b>•</b> • • • • • • • • • • • • • • • •	. 10 100	naliza deresto - e					•	
N POST PLICHT	- 1		SNO		FANKS EXTERNAL LEAK	P. INTER	ら VER	ł				·	•	-	÷			-	•	
FUNCTION	TITLE	2 b	POWER UP PREPARATIONS	Test set up	C PRESSURIZE TANKS		• .					•		•			,		-	
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FLOW BLOCK NO.				•			•				- -						*** ****			
N ZERO NPSH	12			N VALVES		CHECK	STEM		<b>-</b> · ·	•		•• ••		. •	• •					
- MAIN PROPULSION ZERO NPSH	10		CHECK TO ISOLATION VALVES	INTERNAL LEAK CHECK OF ISOLATION VALVES		ENGINE FUNCTIONAL CHECK	SECURE SUBSYSTEM						•		<del></del> -		••• . •			
снескоот - мл	8		THECK TO ISO	L LEAK CHECK	VERIFY PURGES	S ENGIN	5)		:				- · ·				••			
FUNCTION TITLE FOST FLIGHT C	9	SNO	EXTERNAL LEAK	TINTERNA	5			. <u></u>	<u>.</u>	<b>-</b> ·				•••		<b>\</b>				
TITLE	†	POWER UP PREPARATIONS	THEST SET UP	<u>-り</u>				· · · · · · · · · · · · · · · · · · ·	·• •								• • • • • • • • • • • • • • • • • • •	,		
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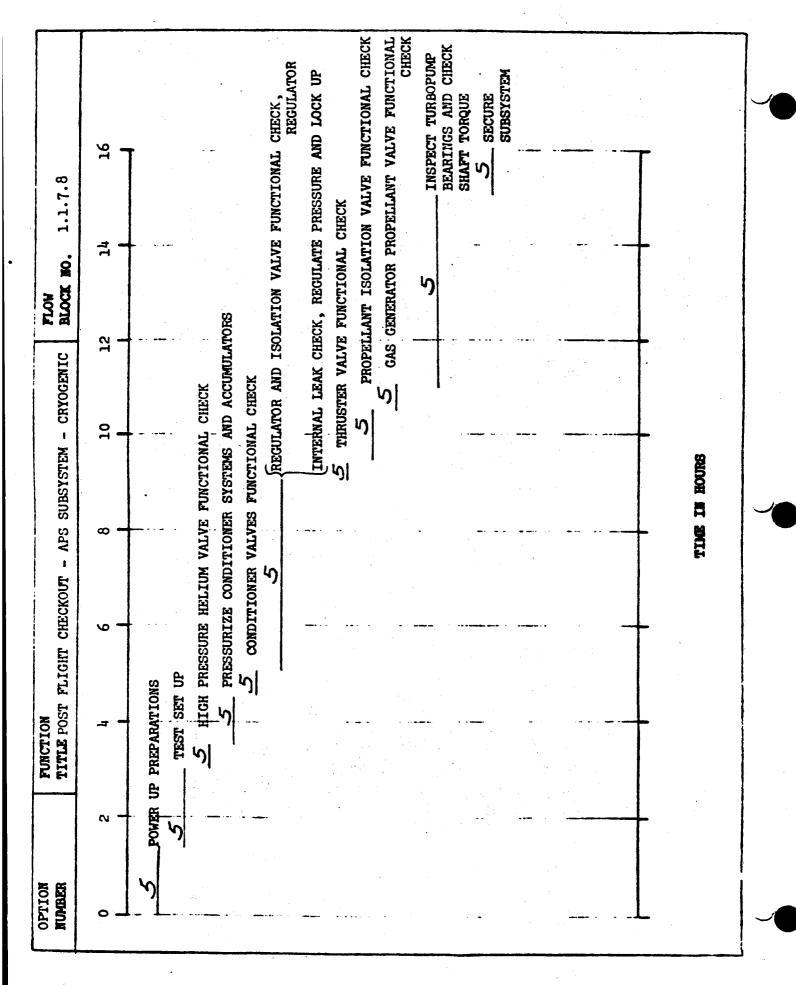
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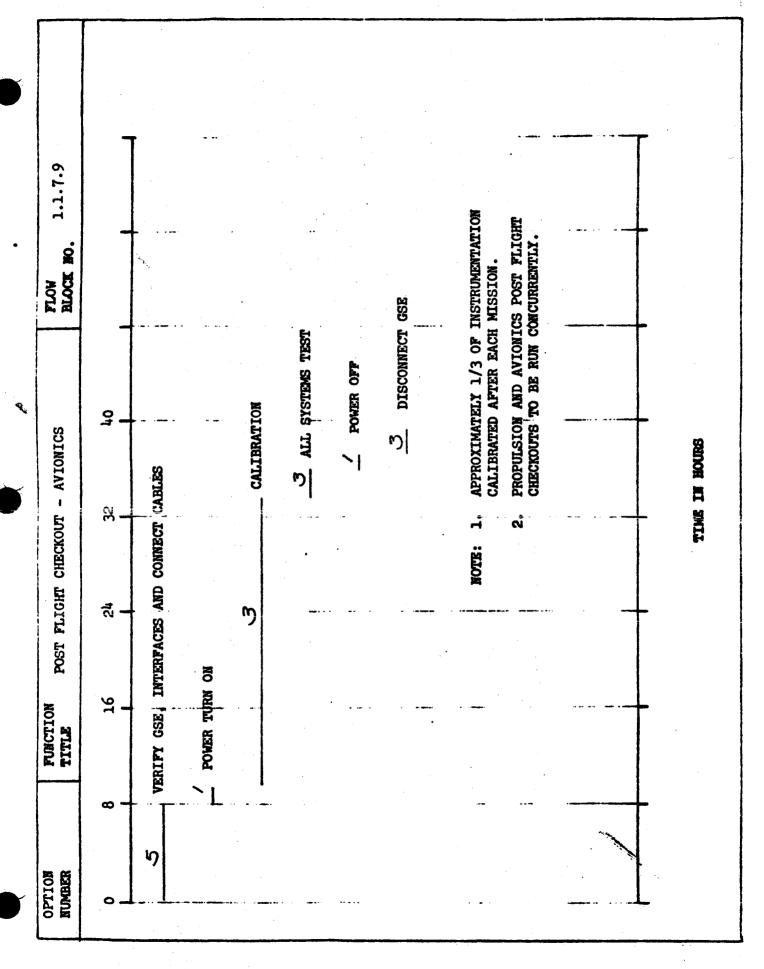


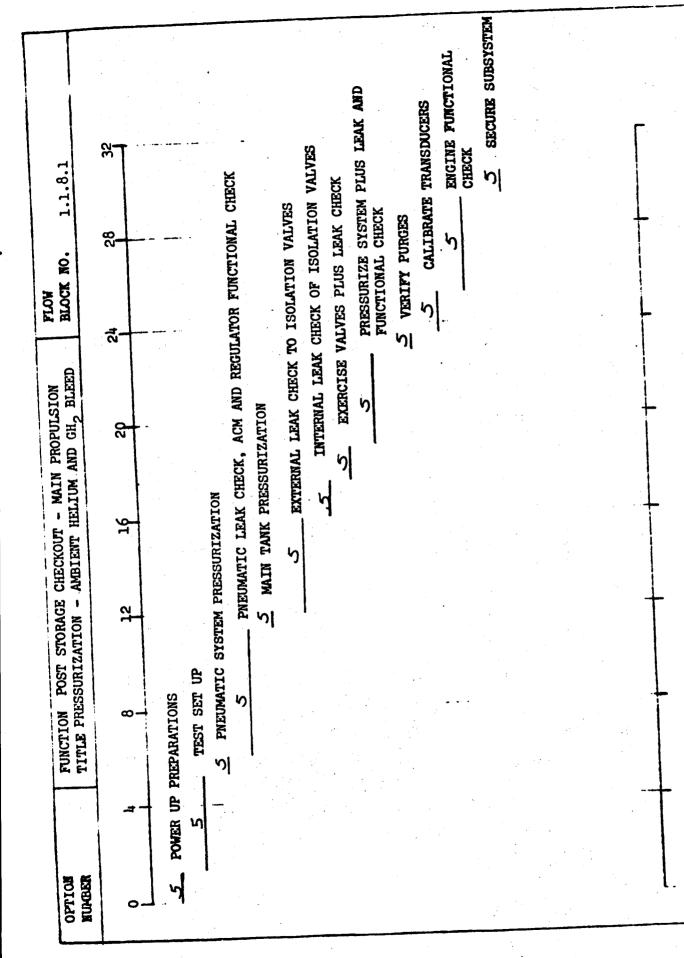
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	TITLE	TITLE BIPROPELLANT			BLOCK NO.	1.1.7.7
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POWIER	POWER ON PREPARATIONS	IONS				
ין	5 TEST	TEST SET UP	•	· •	•••	
	2	PRESSURIZE HELIU	IUM BOTTLE	- <del>-</del>		<b>-</b>
·	- 1	7	REGULATOR A	REGULATOR AND ISOLATION VALVE	E FUNCTIONAL A	REGULATOR AND ISOLATION VALVE FUNCTIONAL AND INTERNAL LEAK CHECK RECHLATE PRESSIRE AND LOCK UP
		•	PRESSI	PRESSURE SWITCH CHECKOUT	. E	
			5	PRESSURIZE LOW PRESSURE SYSTEM	PRESSURE SYSTE	
				5 thruster va	THRUSTER VALVE FUNCTIONAL CHECK	, CHECK
	<b>-</b> · ·	- aan	• <del>•</del>	8	PROPELLANT ISOLATION VAI	PROPELLANT ISOLATION VALVE FUNCTIONAL TANK READER LEAK CHECK
				•	S BECU	SECURE SUBSYSTEM
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			TIME IN HOURS	HOURS		

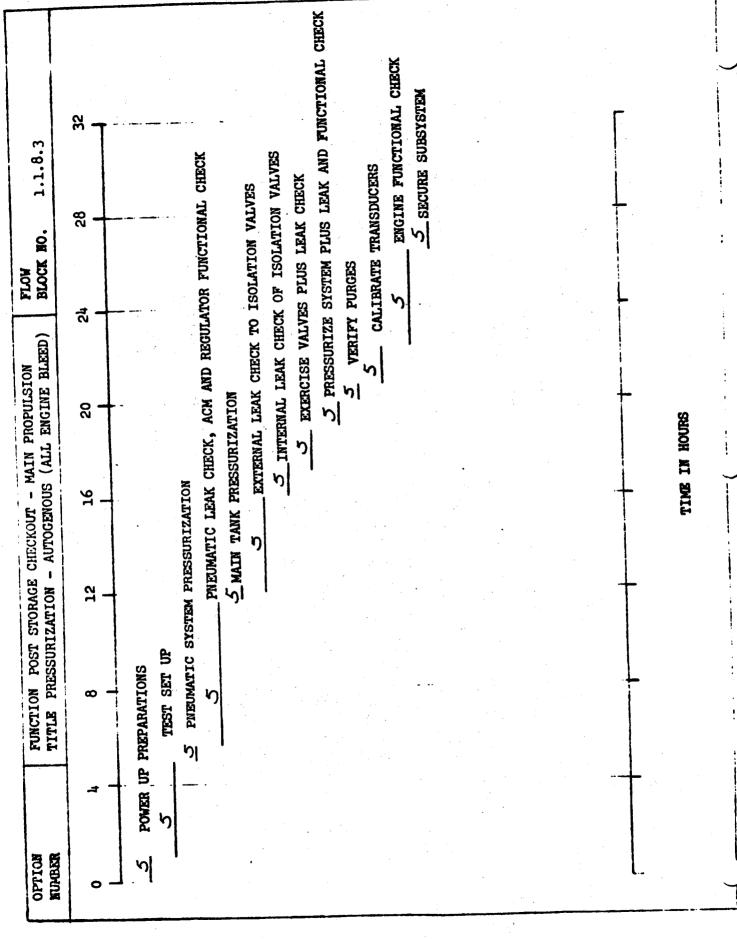


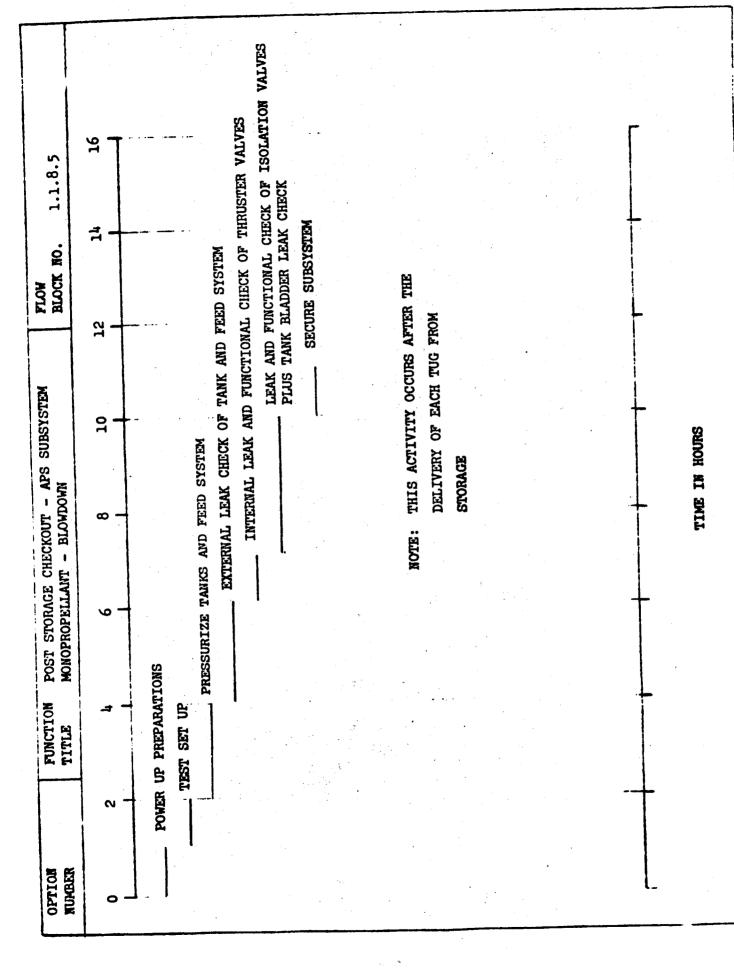




TIME IN HOURS

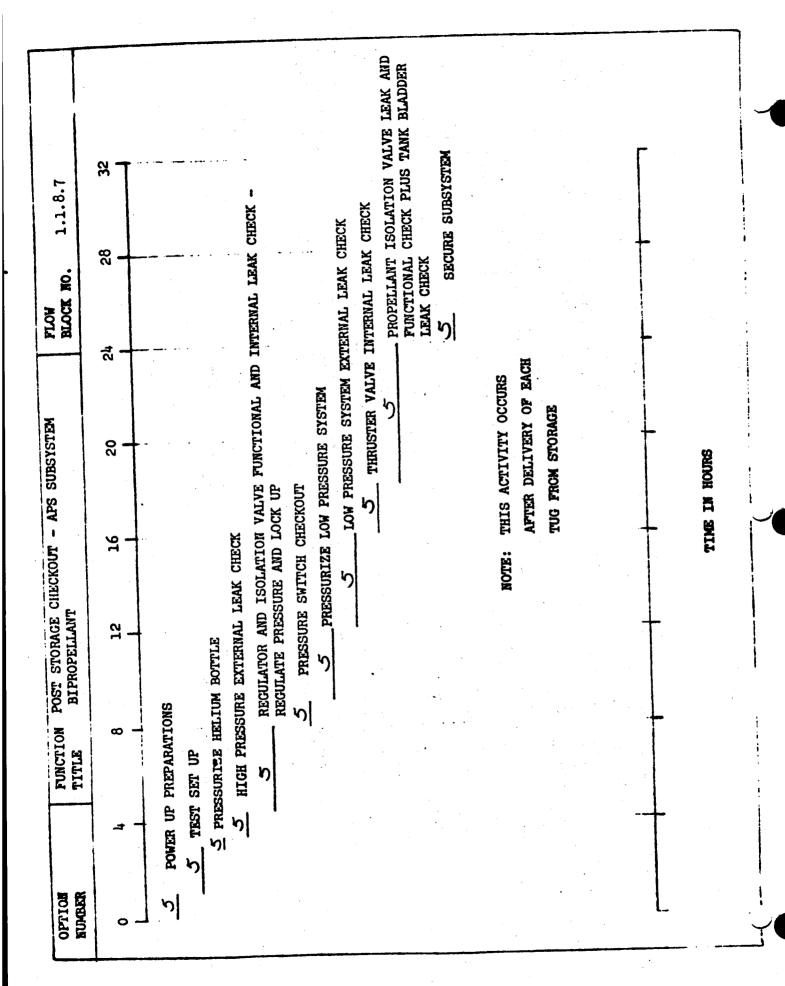
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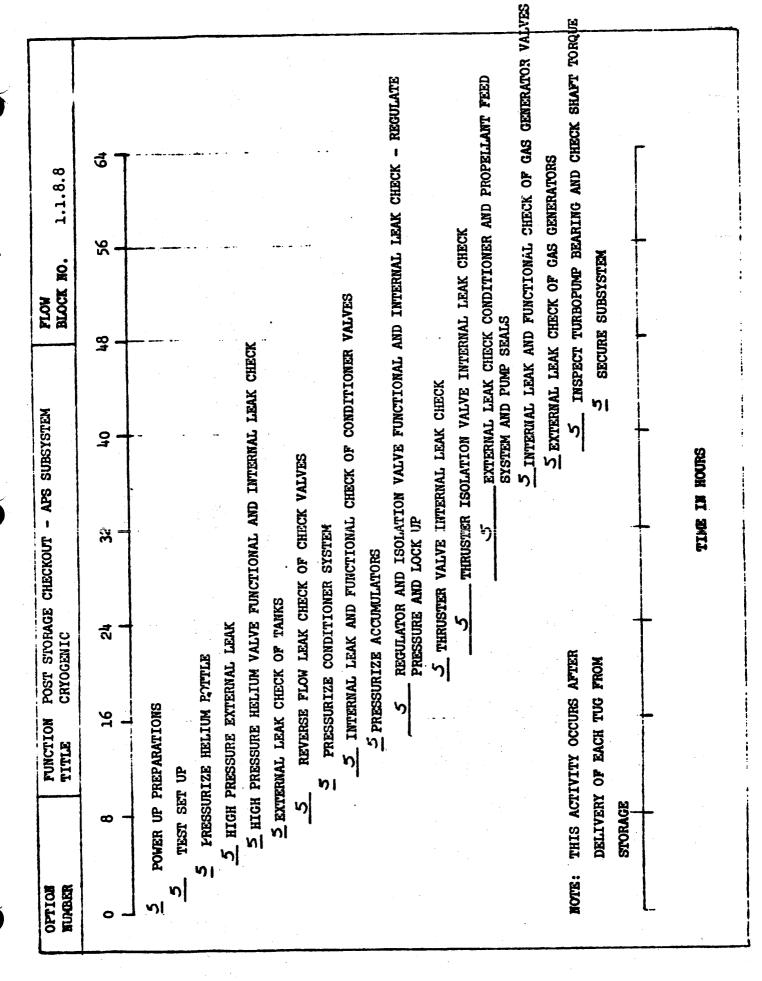


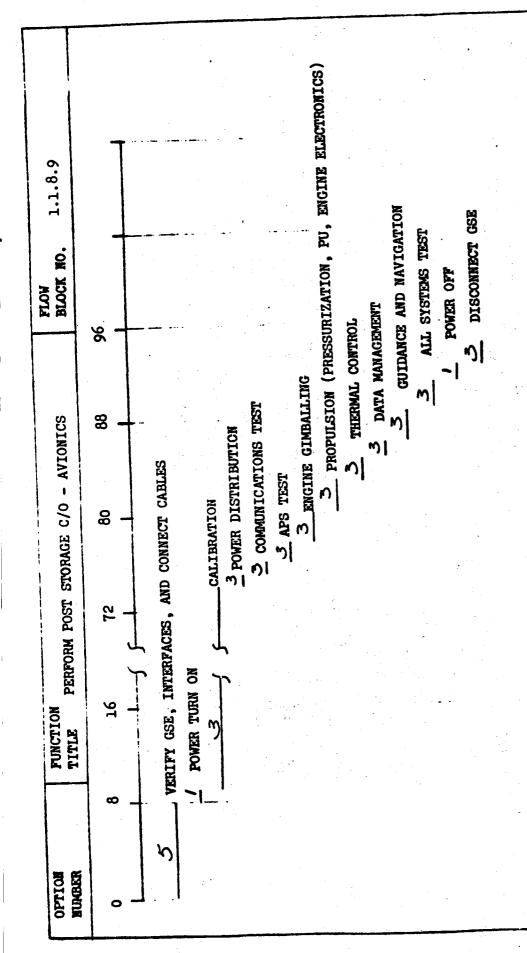


FRESSURIZE HELIUM BOTTLE  THOH PRESSURE EXTERNAL LEAK CHECK  TEGULATOR AND ISOLATION VALVE FUNCTIONAL AND INTERNAL  REQUIATE PRESSURE AND LOCK UP  TEGULATE PRESSURE SUTTCH CHECKOUT  TO PRESSURE SYSTEM  TOWN PRESSURE SYSTEM  THRUSTER VALVE INTERNAL LEAK CHECK  THRUSTER VALVE INTERNAL LEAK CHECK  THRUSTER VALVE INTERNAL LEAK CHECK  THRUSTER VALVE  FLUS TARK BLADDER LEAK CHECK  STORAGE  STORAGE	TTCH CHECKOUT  AIZE LOW PRESSURE SYSTEM  SYSTEM  THRUSTER VALVE INTERNAL LEAK CHECK  THRUSTER VALVE INTERNAL LEAK AND FUNCTIONAL CHECK  THUS TANK BLADDER LEAK CHECK  SECURE SUBSYSTEM  FROM	CHBCK
TIME IN HOURS		

D-159

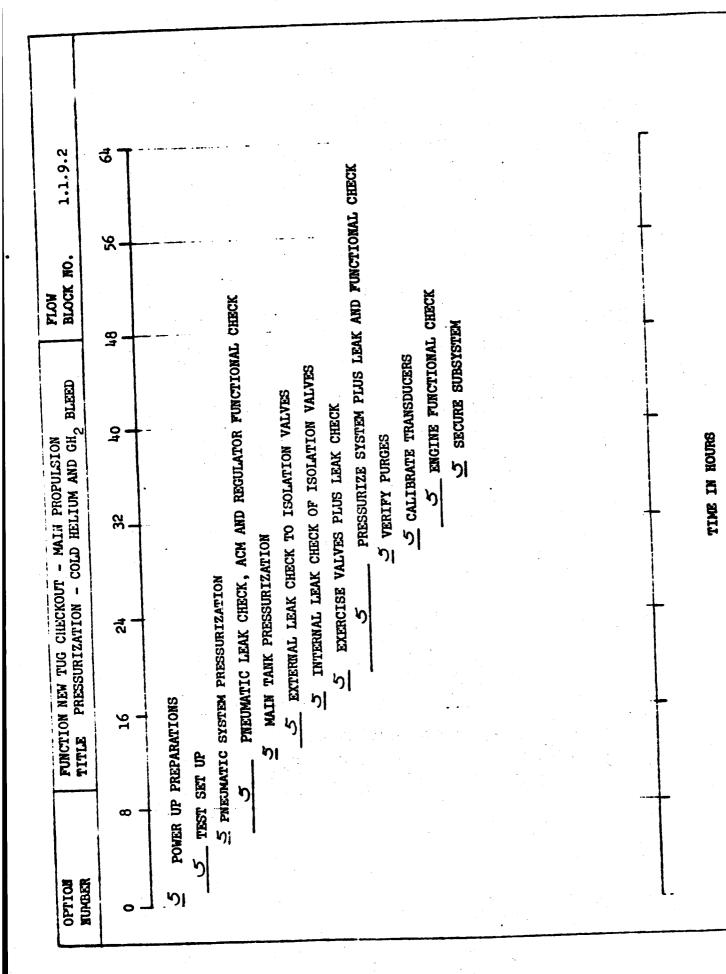




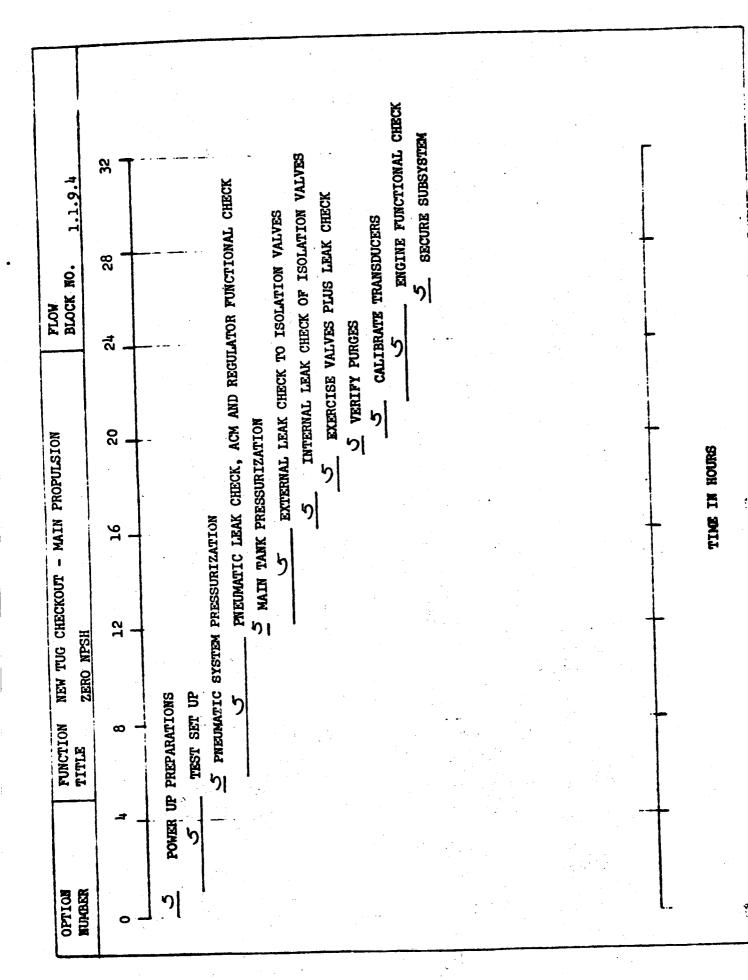


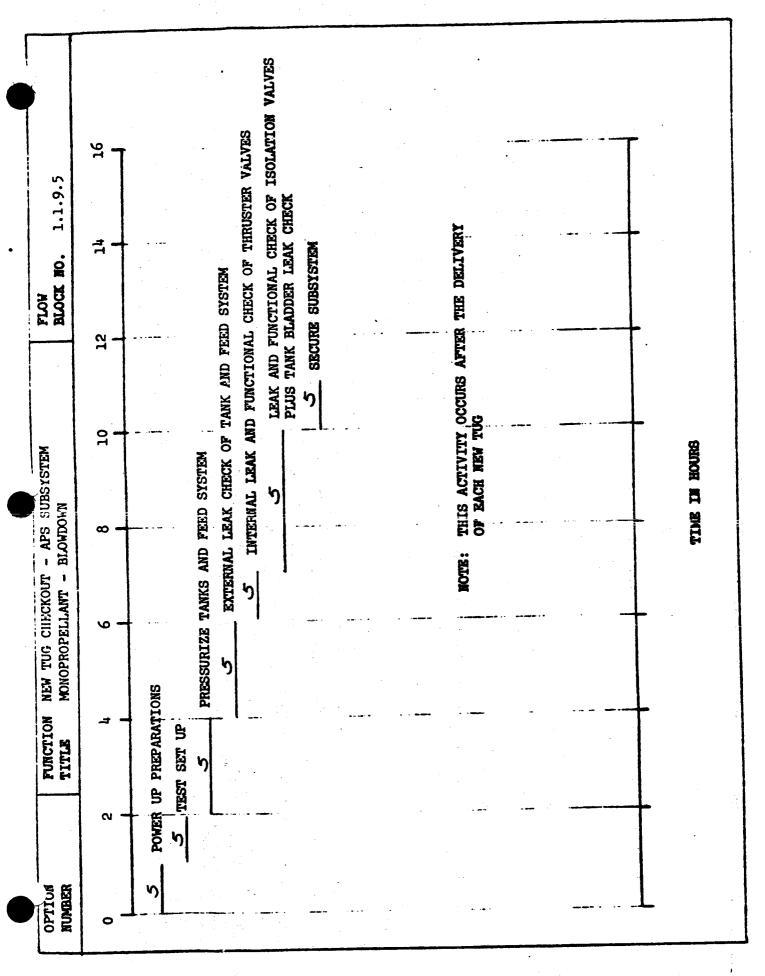
NOTE: THIS ACTIVITY OCCURS EACH TIME A TUG IS REMOVED PROM LONG TERM STORAGE TIME IN HOURS

1.1.9.1	% T		IAL CHECK	VES	ION VALVES AK CHECK	SYSTEM PLUS LEAK AND CHECK	PURGES	ENGINE FUNCTIONAL CHECK	SECURE SUBSYSTEM				<b>A</b>
FLOW BLOCK NO.	24 28		REULATOR FUNCTION	C TO ISOLATION VAL	INTERNAL LEAK CHECK OF ISOLATION VALVES  SEXCESSIVE VALVES PLUS LEAK CHECK	PRESSURIZE SYSTEM FUNCTIONAL CHECK	S VERIET PURGES	<b>5</b>				•	
OUT - MAIN PROPULSION AMBIENT HELIUM AND GH <sub>2</sub> BLEED	50	<u>-</u> -	I PRESSURIZATION PNEUMATIC LEAK CHECK, ACM AND REGULATOR FUNCTIONAL CHECK	RESSURIZATION EXTERNAL LEAK CHECK TO ISOLATION VALVES	S INTERNAL LEAN	א		•			1	-	IN HOURS
ပ္ထို ၊	12 16		STEM PRESSURIZATION PREUMATIC LEAK	MAIN TANK PRESSURIZATION								<b>-</b>	TIME
FUNCTION NEW TUG CHU TITLE PRESSURIZATION	80	POWER UP PREPARATIONS STEST SET UP	S PNEUMATIC SYSTEM			·.				-		-	
	<b></b> -	POWER UF	<del></del>									-	•
OPTION	0-	<b>5</b>										<b>L</b>	

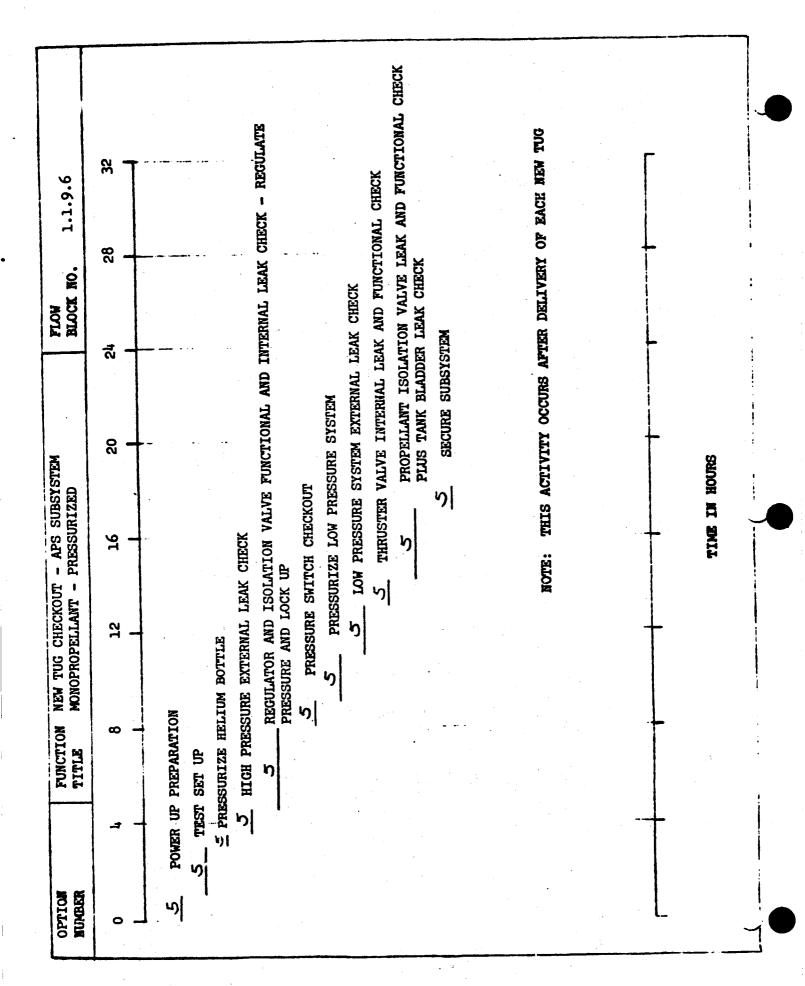


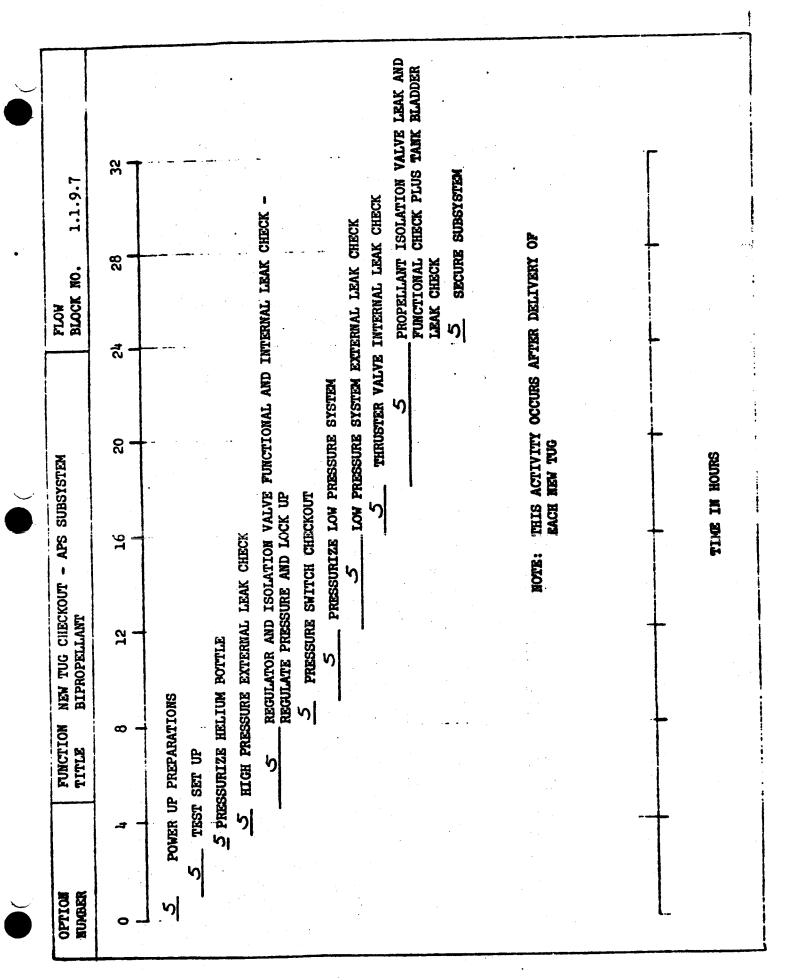
			2. 2.			TTOWAL CHECK		CHBCK	YSTEK			
1.1.9.3	8 32		MAL CHECK	- New Y	ION VALVES	CHECK LEAK AND FING		INSDUCERS ENGINE FUNCTION CHECK	SECURE SUBSYSTEM			Annual Control of the
FLOW BLOCK NO.	24 28		LATOR FUNCTIO	AV MOTHATOST	ECK OF ISOLAT	EXERCISE VALVES PLUS LEAK CHECK	VERIFY PURGES	CALIBRATE TRANSDUCERS	ומ	•		: :
ENGINE BLEED)	50	-	, ACM AND REGU	ZATION	STIERNAL LEAK CHECK OF ISOLATION VALVES	EXERCISE VALV	S VERIE	אן			+	×
OUT - MAIN PROPULSION - AUTOGENOUS (ALL ENGINE BLEED)	<b>1</b> 6		PRESSURIZATION PHEUMATIC LEAK CHECK, ACM AND REGULATOR FUNCTIONAL CHECK	MAIN TANK PRESSURIZATION	EXTERN A	ח					_	TIME IN HOURS
NEW TUG CHECKOUT PRESSURIZATION - AU	12			NAIN S		•					+	
FUNCTION NEW TITLE PRESSU	∞ -	POWER UP PREPARATIONS	PNEUMATIC SYSTEM			•		•	. • 1 • • • • • • • • • • • • • • • • •	<i>:</i>		
	.a	POWER UP										
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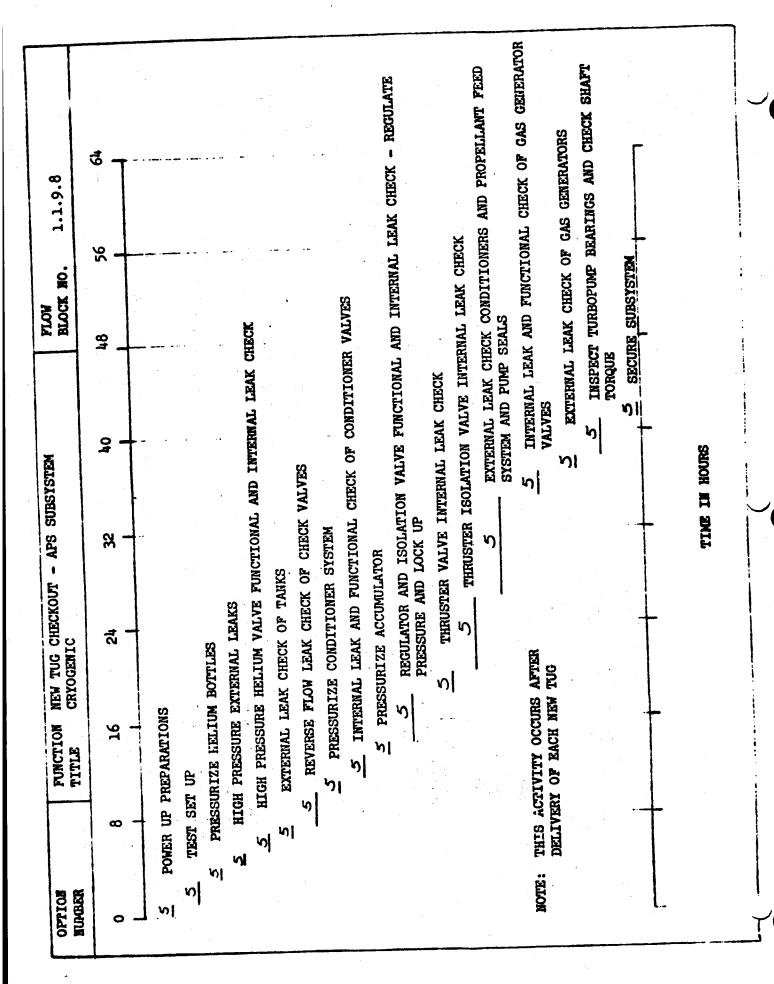




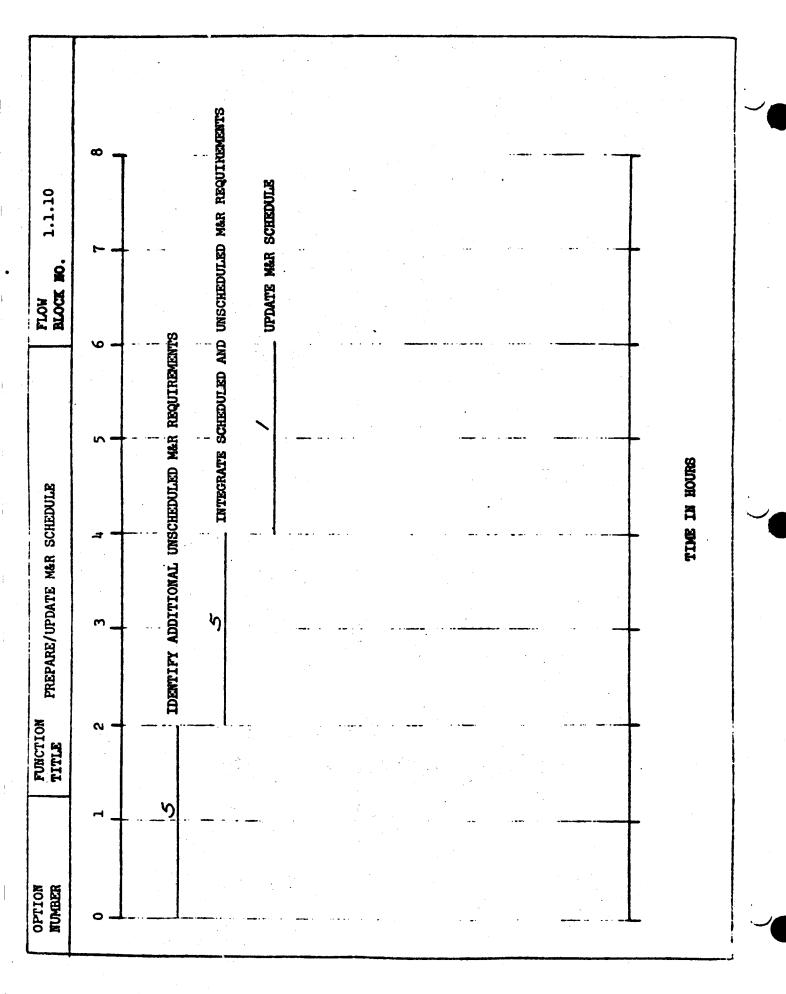
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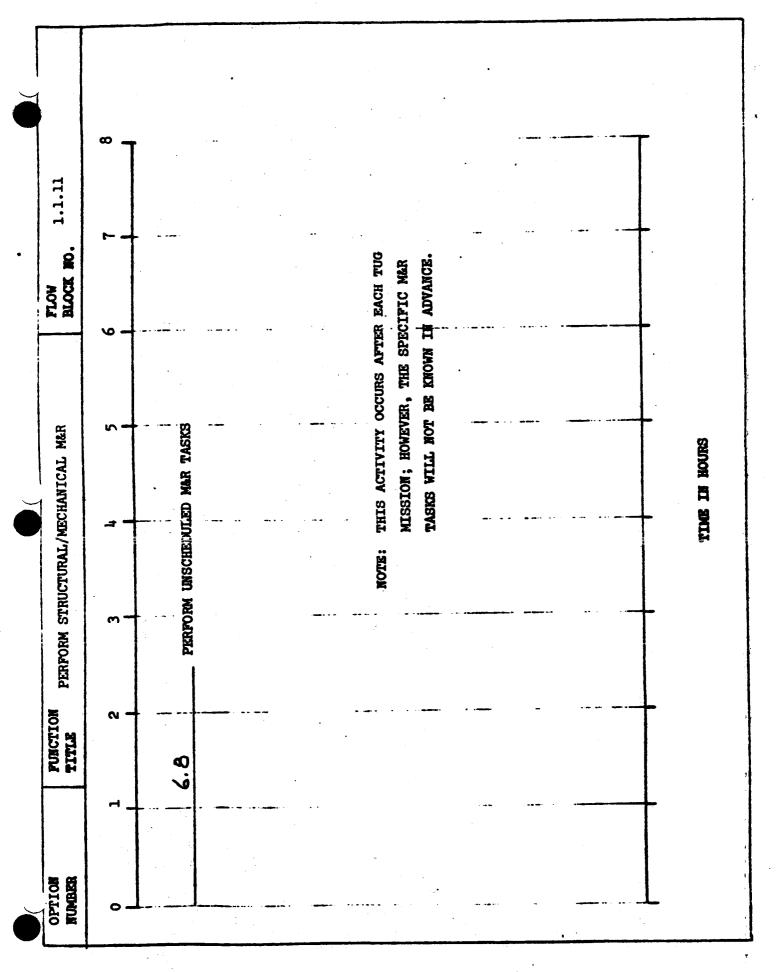






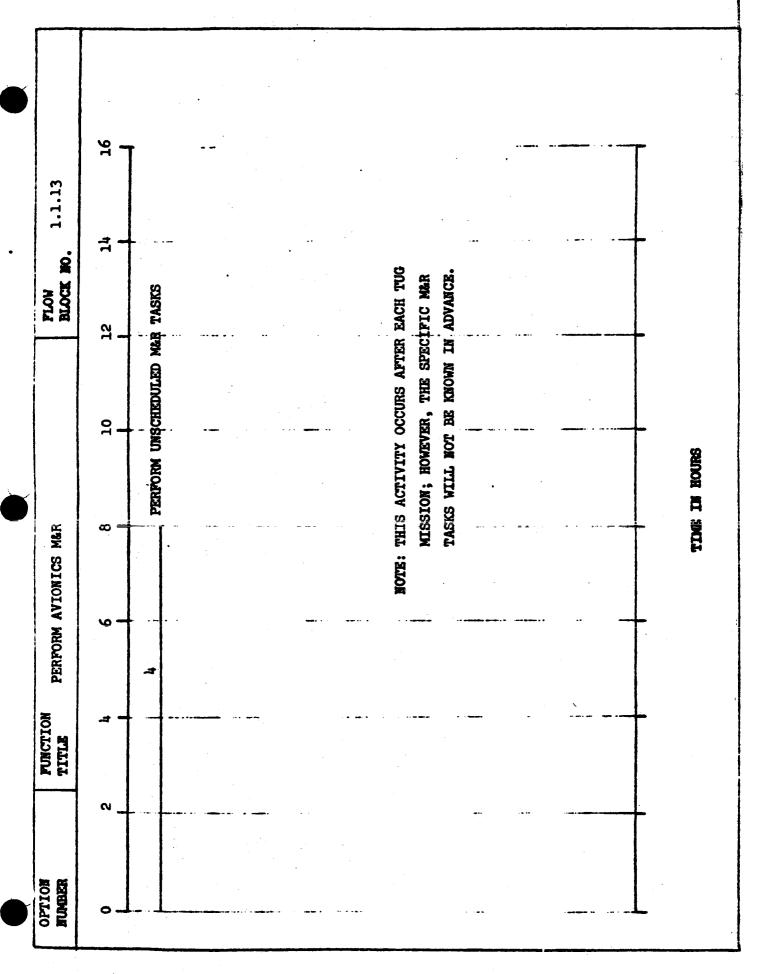
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1.1.9.9						. • 				· · · · · · · · · · · · · · · · · · ·
FLOW BLOCK NO.							USB.	•		
FUNCTION TITLE NEW TUG CHECKOUT - AVIONICS	8 16 24 32 40	VERIFY GSB, INTERPACES AND CONNECT CABLES	POWER TURN ON	CALIBRATION	/ ALL SYSTEMS TEST	/ POWER OFF	3 DISCONNECT	THIS ACTIVITY OCCURS AFTER EACH NEW TUG DELIVERY APPROX. 1/3 OF INSTRUMENTATION CALIBRATED AFTER EACH MISSION PROPULSION AND AVIONICS CHECKOUTS TO BE RUN CONCURRENTLY.		TIME IN HOURS
OPTION NUMBER	0	5						NOTES: 1. 2.		

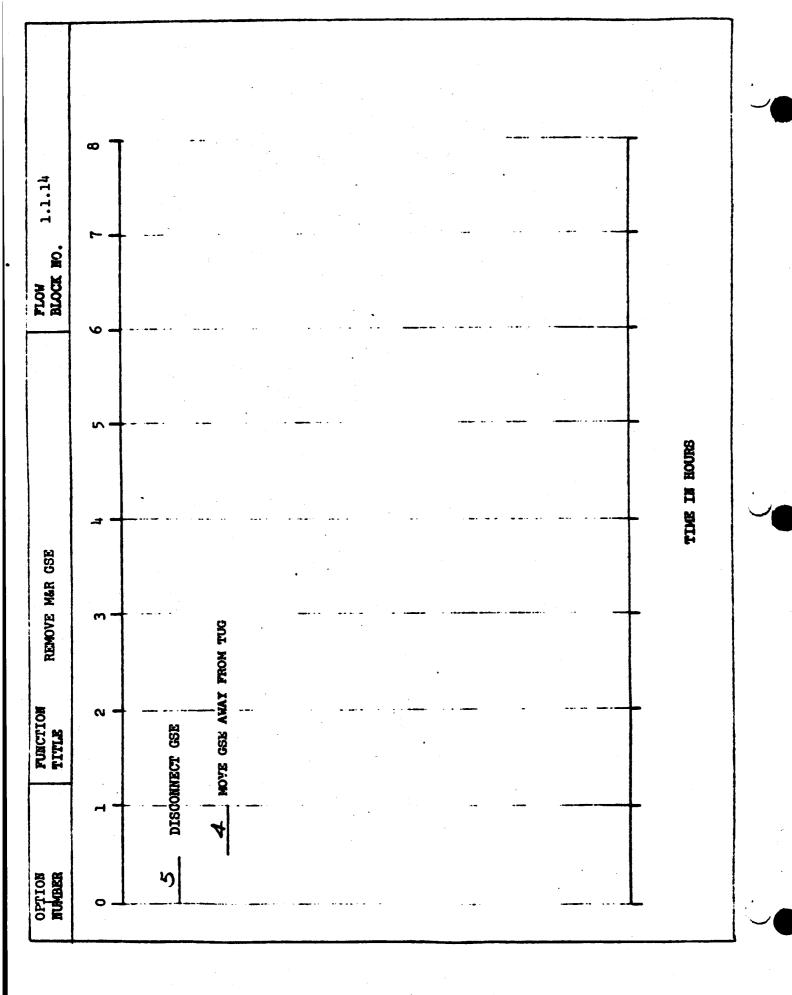


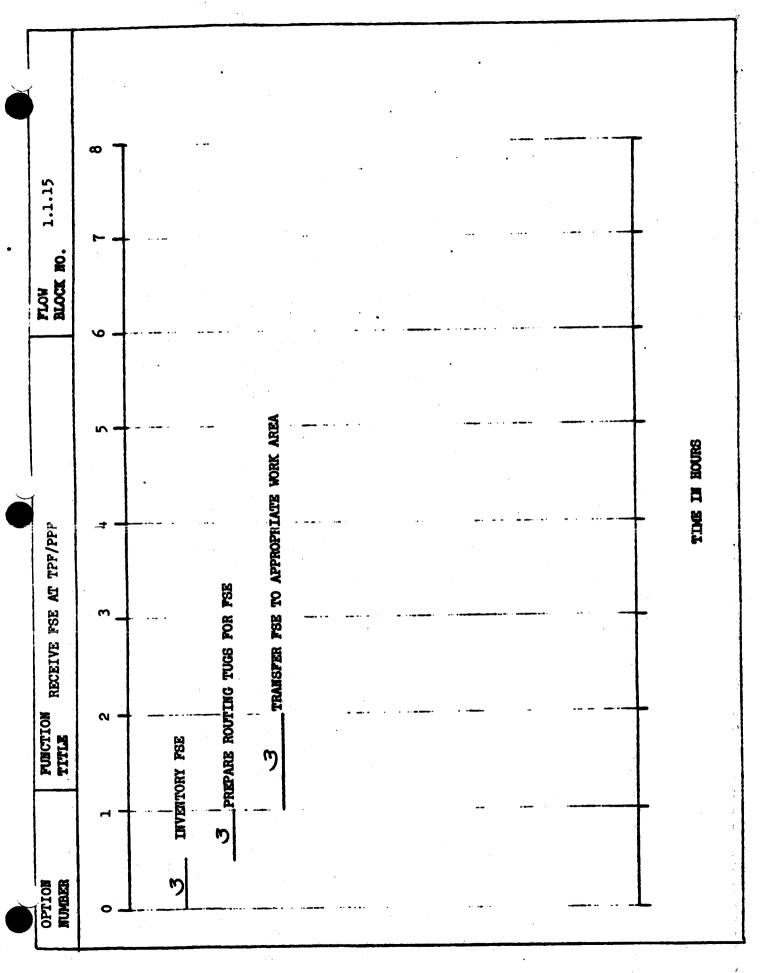


16	97 ]	<del>-</del>	•• •			
BLOCK NO.	12 14 1				AFTER EACH TUG S SPECIFIC MAR NW IN ADVANCE.	
	10	PERFORM UNSCHEDULED MAR TASKS		<del>-</del> :	THIS ACTIVITY OCCURS AFTER EACH TUG MISSION; HOWEVER, THE SPECIFIC MAR TASKS WILL NOT BE KNOWN IN ADVANCE.	TIME IN HOURS
PROPULSION MER	8 9	PERFORM UNS			NOTE:	MIT
PERFORM	·					
TITLE	2	2,5				, ,
OPTION NUMBER	0			·····		-

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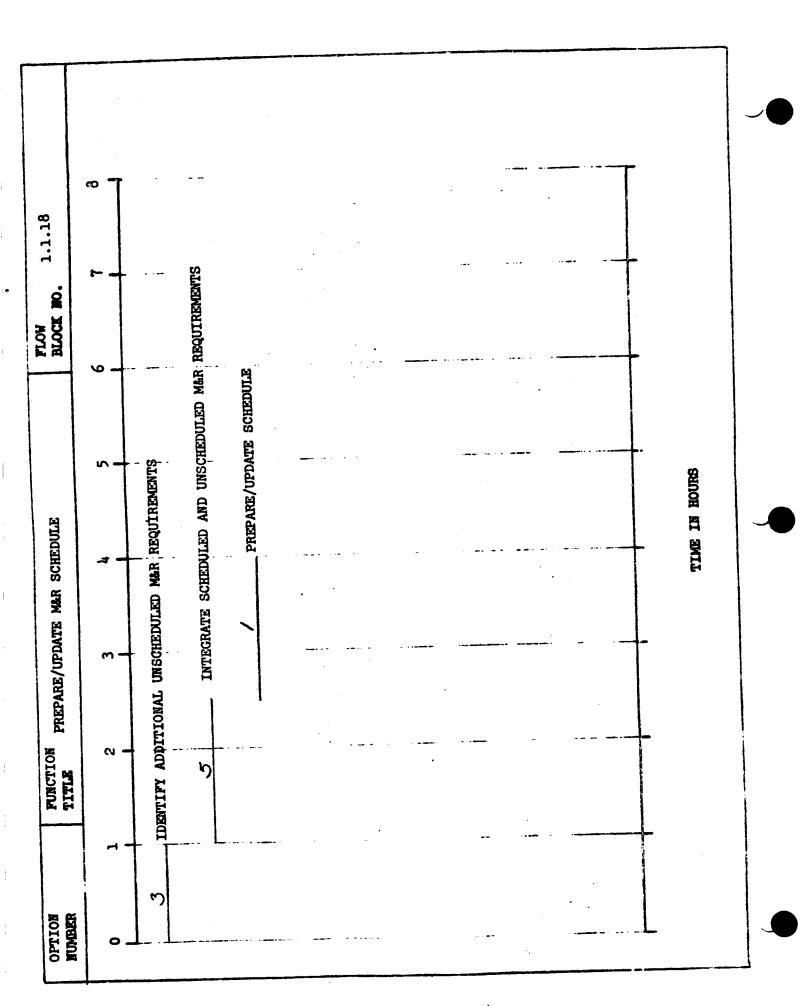


NUMBER	TITLE	PREPARE FOR	K INSPECTION			BLOCK NO.			
0.	τ,	~ _	er =	≉_	r. —	9	<b>-</b> -	∞ ]	
	4	REMOVE TILT	i	TUG AND RE	TABLE FROM TUG AND REMOVE COMPONENTS FROM TILT TABLE (AS REQUIRED)	NTS FROM TI	LT TABLE (	AS REQUIRED	
		4	CLEAN FSE EXTERNAL SURFACES	XTERNAL SUI	PACES			- ··	•
	: : :		4	POSITION/(	POSITION/CONNECT REQUIRED GSE AND GROUND POWER AND PERFORM SELF CHECK	RED GSE ANI	GROUND PO	WER AND	
		an and an an an an an an an an an an an an an							·
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				TIME IN HOURS	en en				

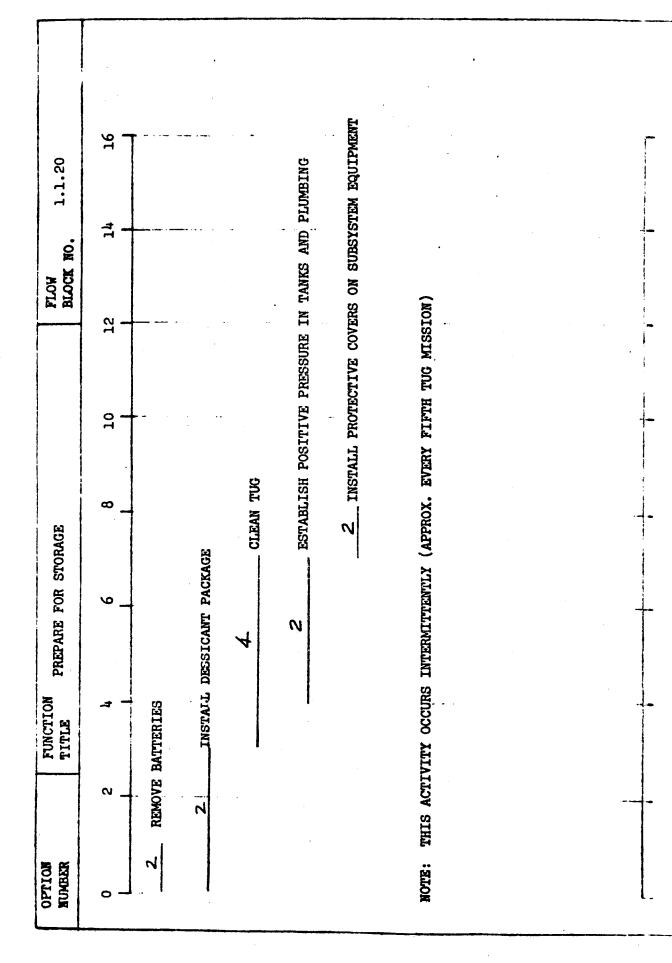
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11.								-	•			
1.1.17	41 -					WARE						
FLOW BLOCK NO.				•		CHMENT HAR	Sa	· .				
PSE POST FLIGHT/RECEIVING INSPECTION	12		MENT		CALS	INSPECT TUG SUPPORT ATTACHMENT HARDWARE	DOCUMENT PSK DISCREPANCIES			· · · · · · · · · · · · · · · · · · ·		i D
SCEIVING I	10		PACE EQUIF		ABLLICALS CAL UMBILI	ect tug su	MENT FSE I	• • • • •		<u></u>		HOURS
CGHT/RI	æ <b>-</b>	· 	INTER	)IPMEN	LECTRI	INSP		· · ·		•		TIDE IN HOURS
E POST FL			AND WARNING INTERFACE EQUIPMENT	SUPPORT EQUIPMENT	INSPECT FLUID UMBLLICALS INSPECT ELECTRICAL UMBILLICALS	9						H
Perform FS	6		INSPECT CAUTION AN	INSPECT RMS S				· · · ·				
FURCTION TITLE	4	INSPECT TILT TABLE	INSPECT	Z IN			7		- A March	**		
	8 -	INSPECT	7			<u>.</u>				e e eer		
OPTION NUMBER	0 -	"		·			-				Grande I I I I I I I I I I I I I I I I I I I	

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TIME IN HOURS

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PORT	<b>-</b>		OWER	- E			•	·		•		
FOR TRANSPORT		NELS	INSTALL FUG PROTECTIVE COVER	AND HOOK UP TO PRIME	•						OFFICE STREET, W. C.	
FOR	m -	SS PA	TRCE	AND			e e e e e e e e e e e e e e e e e e e				and the second of the second o	
PREPARE		CLOSE AND SECURE ACCESS PANELS	G PRC	AREA								
		CURE	F. 11	CLEAR ARE								
FUNCTION	2	:S	INST	4		·• <del>-</del> · ·		•	· į		vialwies	
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1.1.22	8 T		E COVER	  MISSION)			
BLOCK NO.	9	<u>.</u>	IN STORAGE AREA AND REMOVE TUG PROTECTIVE COVER	INTERMITTENTLY (APPROX. EVERY FIFTH TUG MISSION)	<b></b> .		
	5	STORAGE AREA	orage area and rie	MITTENTLY (APPROX			TIME IN HOURS
TRANSFER TO STORAGE	e –	TRANSPORT TUG FROM TPF/PPF TO STORAGE AREA	POSITION TUG IN ST	THIS ACTIVITY OCCURS INTE			
FUNCTION TH	2 -	TRANSPORT TUG	4	NOTE: THIS ACTI			
OPTION NUMBER		4					. <b>.</b>

		FUNCTION	1	PERFORM STORAGE SUPPORT		FLOW BLOCK NO.	7	1.1.23
	1	2	e e	4	5 -	9 -	7	ω ¬
	INSPI	ecr dessi	CANT PACKAG	INSPECT DESSICANT PACKAGES AND MONITOR PURGES	ES			
		4	Benice/Repl	SERVICE/REPLACE DESSICANT PACKAGES AND PURGE LEVELS	iges and purge	LEVELS		<u></u>
e.	: • • ·	,	4	MAINTAIN RECORDS AND LOGS	ND Logs	•		•
. "				4 PERFO	A OTHER PREUM	Perpora other pheumatic maintenance as require	- ₩	s require

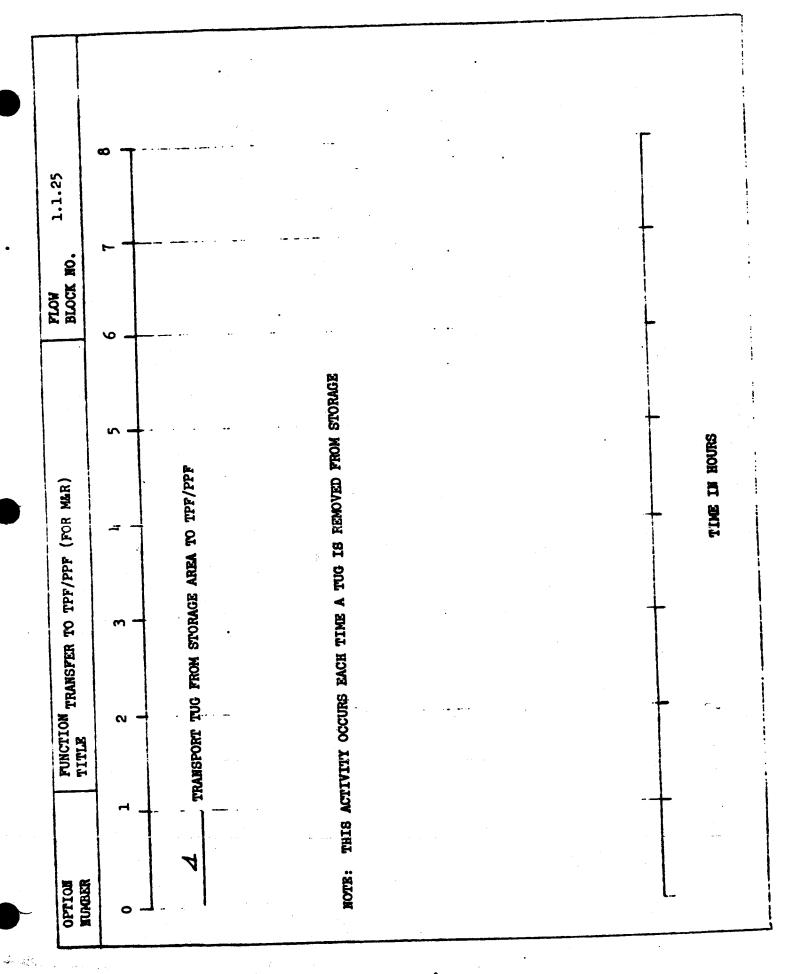
OPTION

THIS ACTIVITY IS PERFORMED PERIODICALLY WHILE TUG IS IN STORAGE HOTE:

PINE IN HOURS

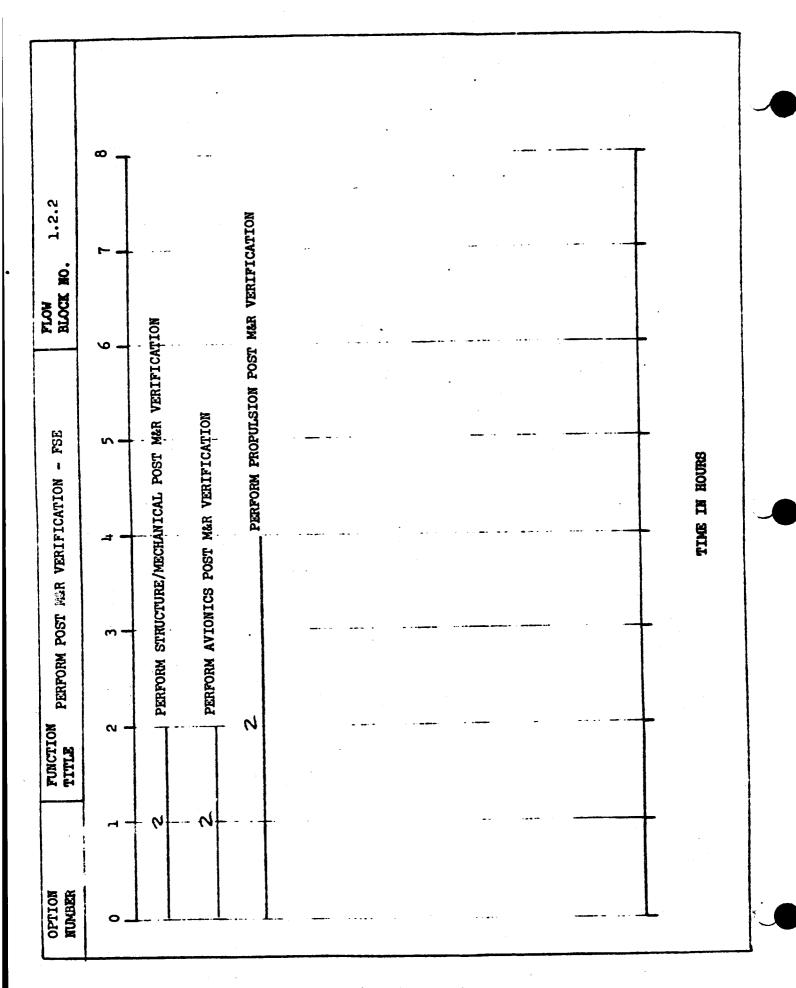
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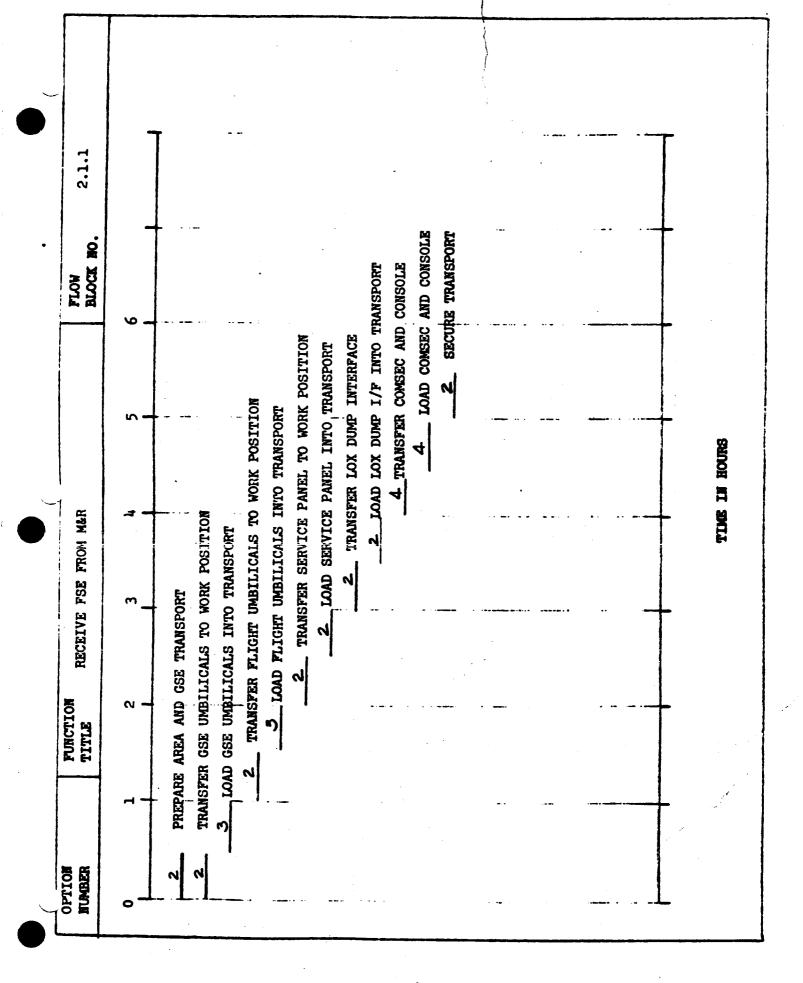
	<b>~ 7</b>				
1.1.24					
REMOVE FROM STORAGE BLOCK NO.	3 4 5 6	FOR GENERAL CONDITION CHECK RECORDS/LOGS AND IDENTIFY SUBSYSTEM DISCREPANCIES	INSTALL TUG PROTECTIVE COVER   PREPARE FOR TRANSPORT	RS EACH TIME A TUG IS REMOVED FROM STORAGE	TIME IN HOURS
FUNCTION	2	INSPECT TUG FOR GENERAL  CHECK RECOR		THIS ACTIVITY OCCURS EACH TIME	
OPTION	6	4		NOTE: THIS	



TRANSPO	PORT TUG	TRANSPORT TUG FROM TPF (OR PPF) TO PRELAUNCH AREA  POSITION TUG IN PRELAUNCH AREA AND REMOVE TUG PROTECTION COVER	PPF) TO F	OR PPF) TO PRELAUNCH AREA  J IN PRELAUNCH AREA AND RE	EA	9	-	<b>ω</b> -	
	ORT TUC	FROM TPF (OF POSITION TUG 1	PPF) TO F	PRELAUNCH AR	EA				
4		I DUT MOITISOG	N PRELAUM	H AREA AND					
	-				REMOVE TUG 1	PROTECTION	COVER		
				• •					
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FLOW 1.2.1 BLOCK NO. 1.2.1	7				
	5 6	ICATION	ST MER VERIFICATION	M&R VERIFICATION	TINGS IN HOURS
N POST M&R VERIFICATION	e -	PERFORM STRUCTURES POST MAR VERIFICATION	PERFORM PROPULSION POST MAR VERIFICATION	PERPORM AVIONICS POST MAR VERIFICATION	•
OPTION FUNCTION NUMBER TITLE	- 2	2 PERFORM STR	- 77-	2	



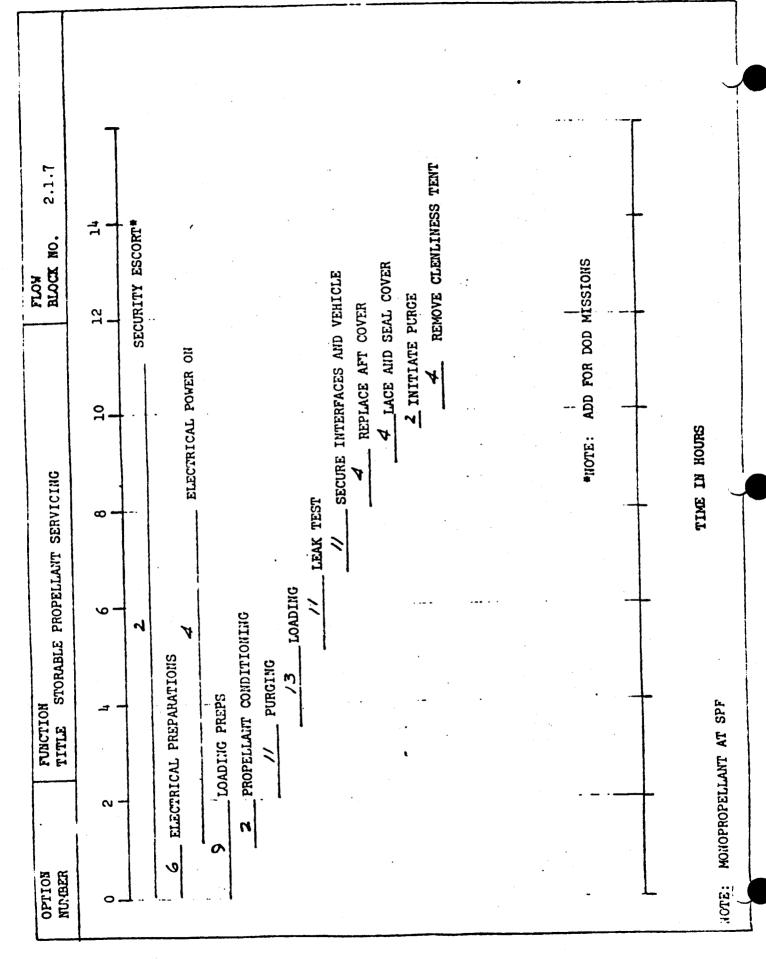


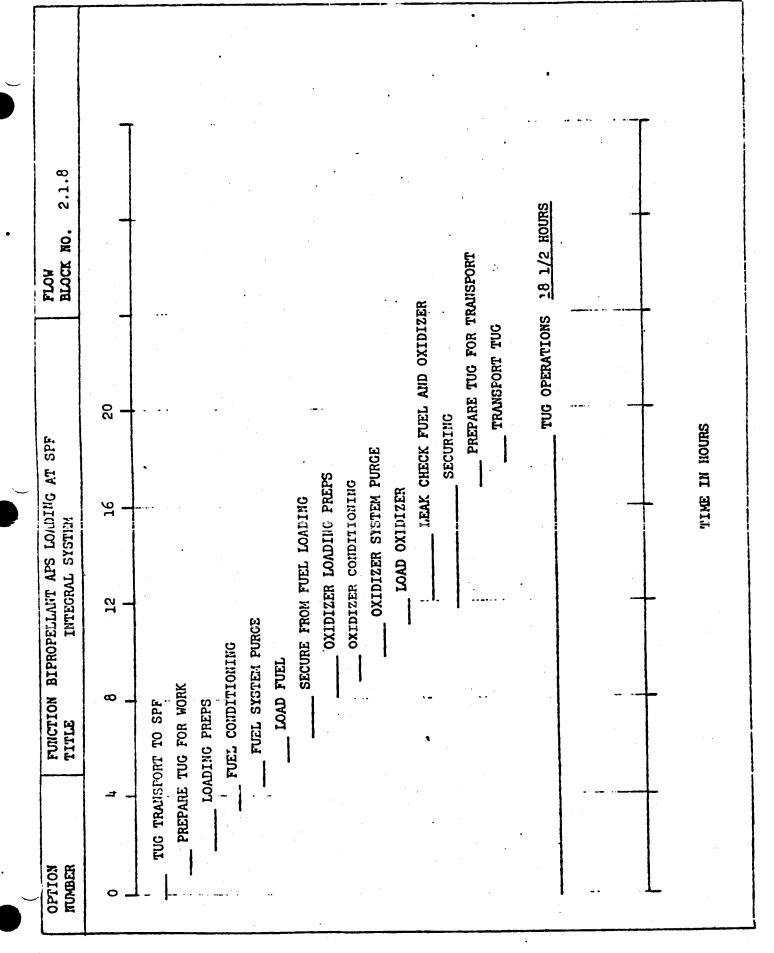
				INSTALL SIDE WORK STANDS	POSITION TRANSPORTER	TRANSFER TUG TO WORK STATION	PREPARE AREA	2 3 4 5	
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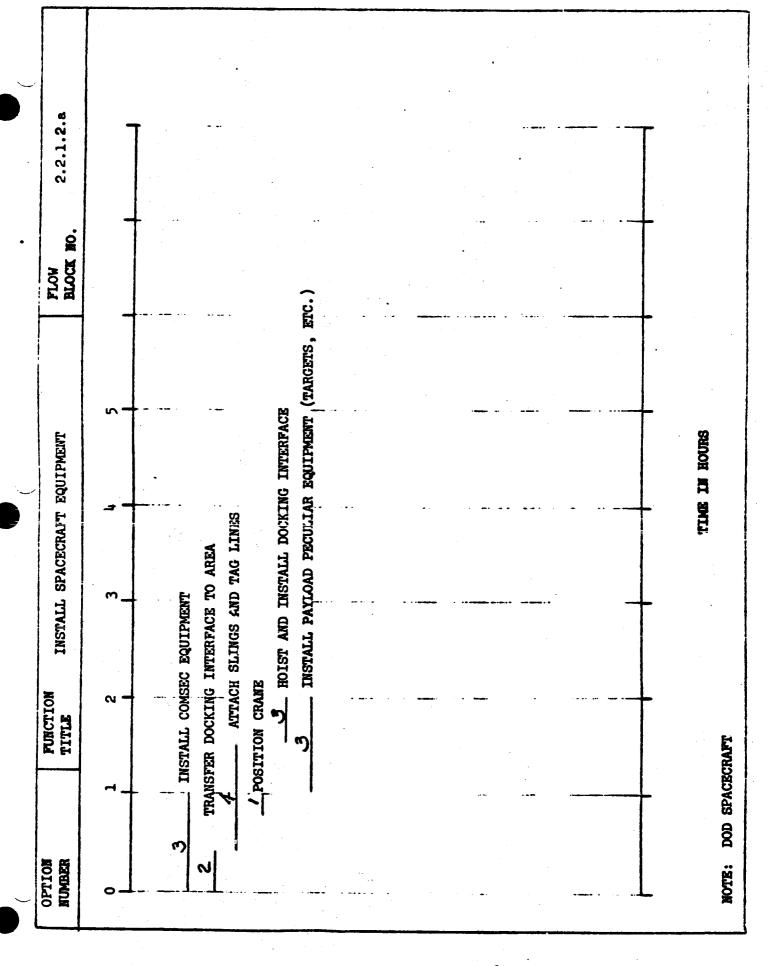
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2.1.3		7		~ ~							*******	•·· <del>· -</del>			·
FLOW BLOCK NO.					•					; <del>-</del>	• •···				
	5				•	- <b>-</b>	- Marina						dulle empunium		
ANSFER	4		-	DRAPE	AND DRAPE	SEAL BEANS	** *** *	·							TIME IN HOURS
TUG FOR PFF TRANSFER	£ .		LIFT CENTER COVER AND DRAPE	LIFT FORWARD COVER AND DRAPE	LIFT AFT COVER AND DRAPE.	4 8K		• ••• •	 ~~~	· · · · · · · · · · · · · · · · · · ·	P-18 - 1177111111111111111111111111111111	· • •			TIM
FUNCTION TITLE PREPARE TU	~	KRS	T CENTER COV.	LIFT FORWA	1 8				 no accept			• • • • • • •			
FUNCTIC	н.	UNPACK COVERS	4 LIF	9		<del>-</del>						****			
OPTION NUMBER	0 -	N				· ·		· •••	÷						
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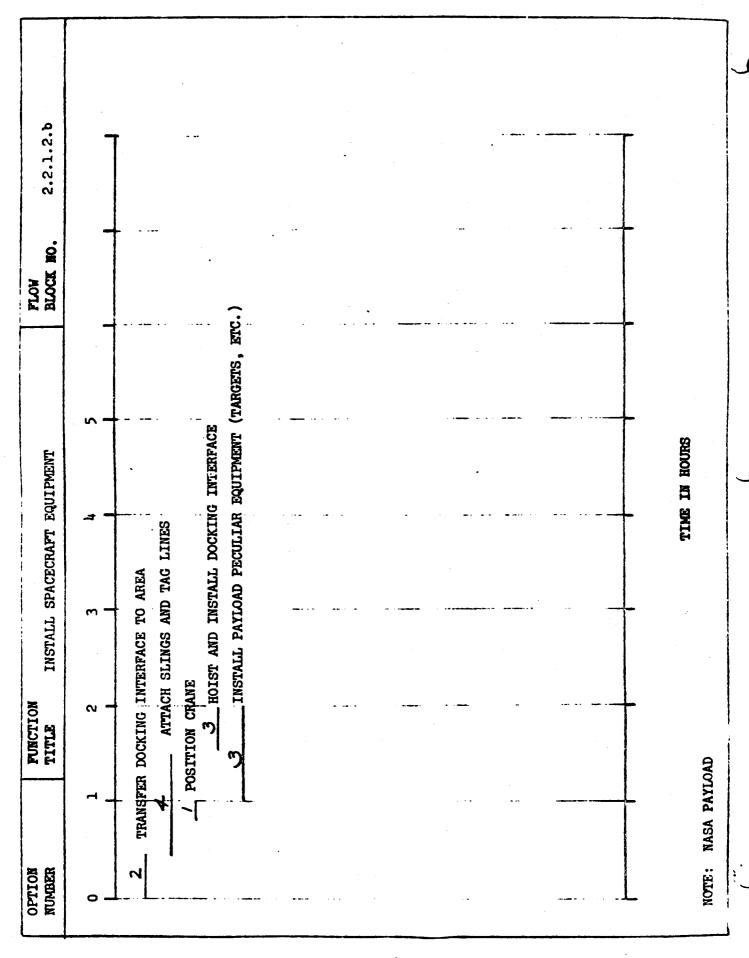
2.1.4									-				 				
FLOW BLOCK NO.	-									TION	***************************************	· <u>-</u>	 - 	 -	-		
FUNCTION TRANSFER TUG TO PPF	2 3 4 5	MATE PURGE INTERRACE AND VERIFY	INITIATE PURGE	ATTACH TRACTOR AND CLEAR AREA	2 POSITION TRANSPORT IN AIRLOCK	/ AIRLOCK FLOW	4 REMOVE FORWARD COVER	POSITION CRANE	M	Z TRANSFER TO WORK STATION						TIME IN HOURS	
OPTION NUMBER	0 -	2 MATE P	1	2		<b>-</b>			·· • • •					 			

	2.1.5	-								•	
· MOTA	BLOCK NO.	9			·			•	IONS		
		5			ENGE	E FLOW REMOVE AFT COVER	SECURITY ESCORT*		ADD FOR DOD MISSIONS		 <b>-</b> 92
	PAYLOAD TKI SPF	<b>₹</b>			SPORTER DOCTORON FINESS TENT	INTERIATE FLOW  A REMOVE	SECURIT		*HOTE: AD		 TIME IN HOURS
•	TRANSFER PAYLOA	-3	E AND VERIFY	furge Ractor and clear are Transfer to spf	2					-	<b>-</b>
- 1	TITLE	- S	MATE PURGE INTERFACE AND VERIFY	ATTACH TRACTOR AND CLEAR AREA  2 THANSFER TO SPF	2 P08		N	•	· <del>-</del>		<b>-</b>
OPTION	KUMBER	0	2 MATE	12							
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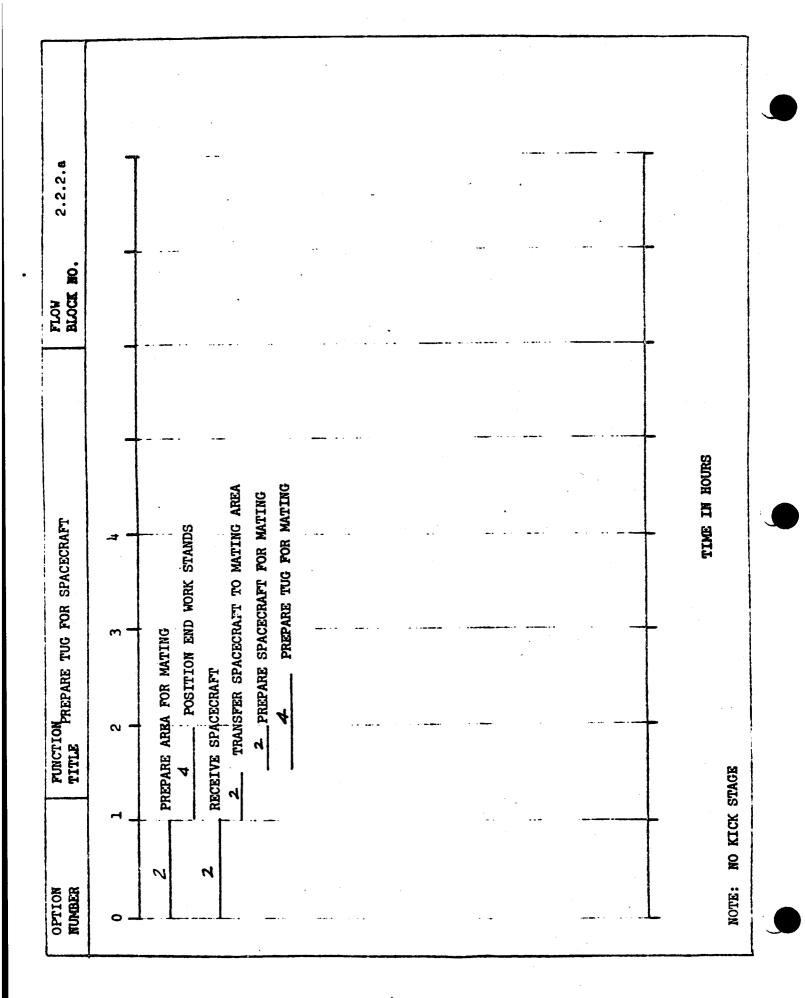




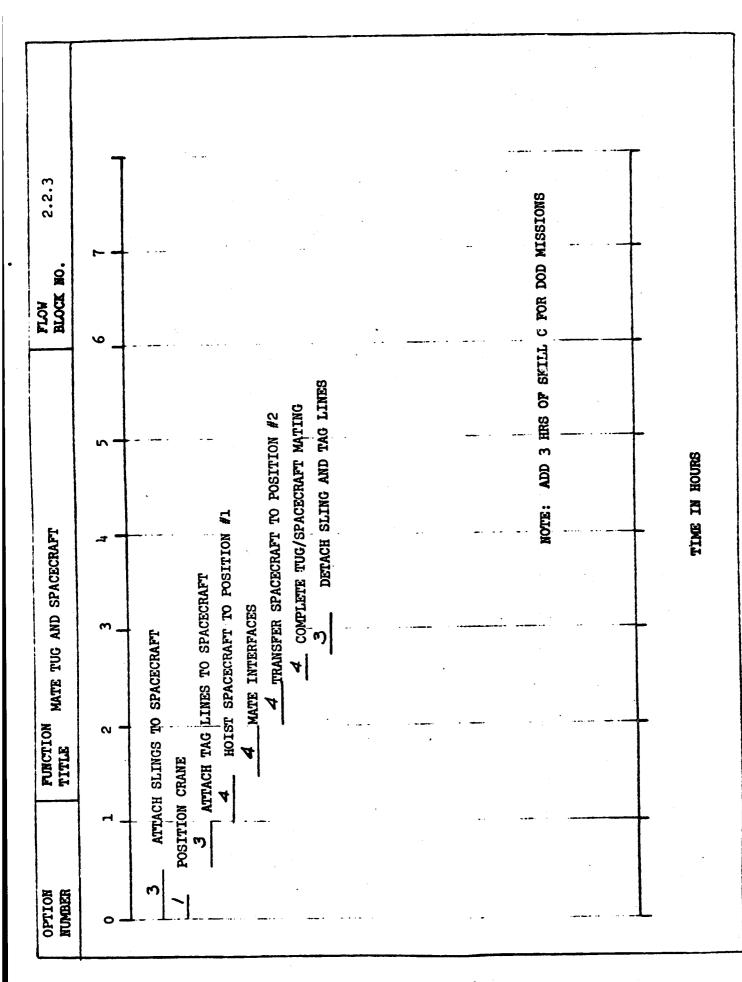




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FLOW BLOCK NO.	-							***********	 			-	
JIP. INTERFACES		<u>.</u>		-		· <del></del> ·-·	• • • • • • • • • • • • • • • • • • •		 - <b></b>	-			HOURS
FUNCTION TITLE VERIFY TUG-TO-SPACECRAFT EQUIP.	9 _	SE .	ON	- !	DISCONNECT GSE			· · · · · · · · · · · · · · · · · · ·	 •			-	TIME IN HOURS
FUNCTION TITLE VERIFY TO	<b>4</b> _	CONNECT CABLES/VERIFY GSE	POWER TEST/POWER	14 POW	~		. • · • · • · ·					-	
OPTION	0 2 1	4 CONNECT	*			·			 			<b>-</b>	

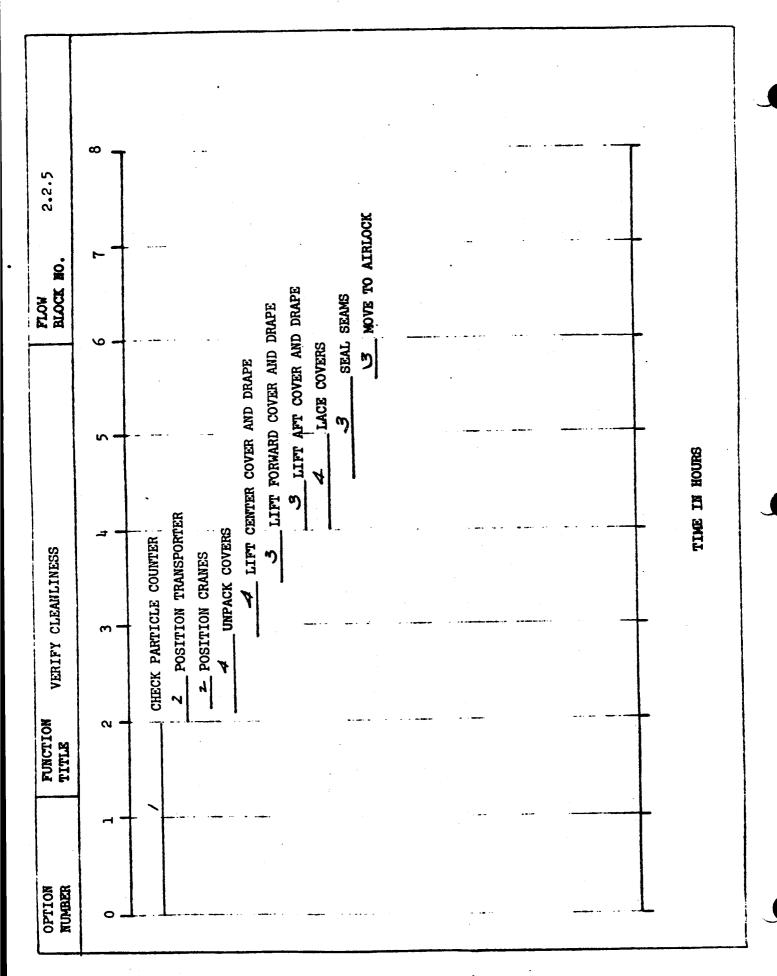


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FLOW	9				· . •	• .	•		·	· · · · · · · · · · · · · · · · · · ·	- ·	<b>-</b>	
R SPACECRAFT	5 4			MATING AREA	POR MATING	FREPARE TUG FOR MATING	MATE KICK STAGE		•		• • • •	•	TIME IN HOURS
ON PREPARE TUG FOR SPACECRAFT	2 1	PREPARE AREA FOR MATING	, MC		PREPARE SPACECRAFT FOR MATING	FREPARE KICK STAGE  FREPARE TO  STAGE  FREPARE TO  FRE				· · · · · · · · · · · · · · · · · · ·	·	 •	
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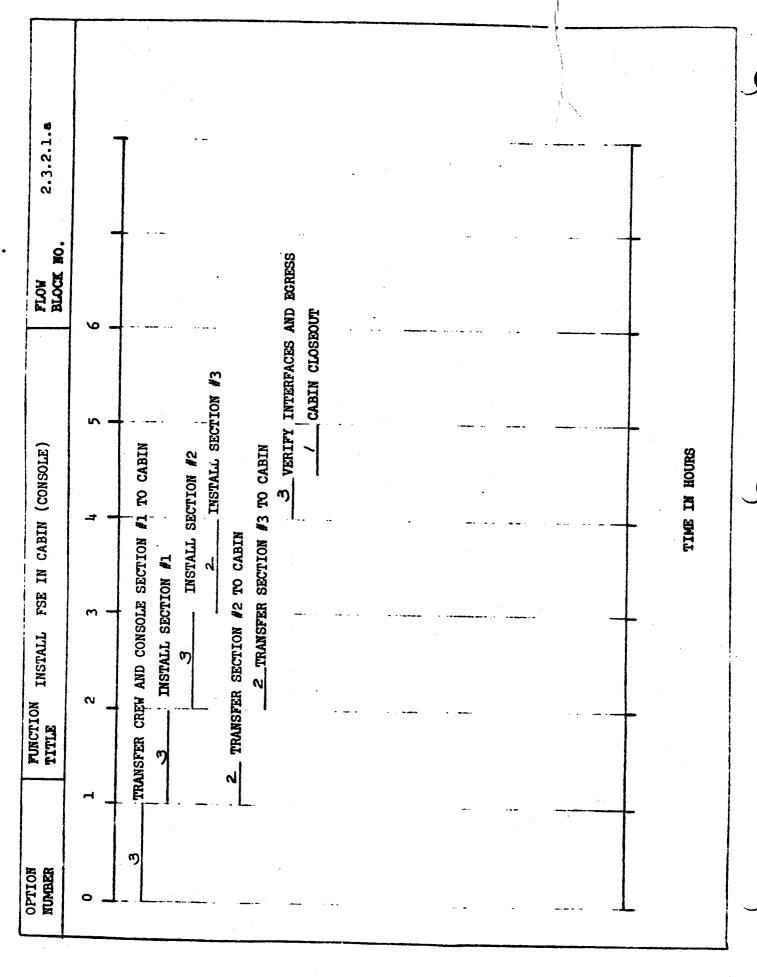


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VERIFY TUG-TO-SPACECRAFT INTERFACES	8 10		- <del>-</del> -	VALIDATE INTERPACES	5 POWER SHUTDOWN	DISCONNECT GSE AND CABLES					-		TIME IN HOURS
1 1	9 -	CONNECT CABLES/VERIFY GSE	POWER TEST/POWER ON	6 VALIDA	2 POW	4				• • • • • • • • • • • • • • • • • • •	•		
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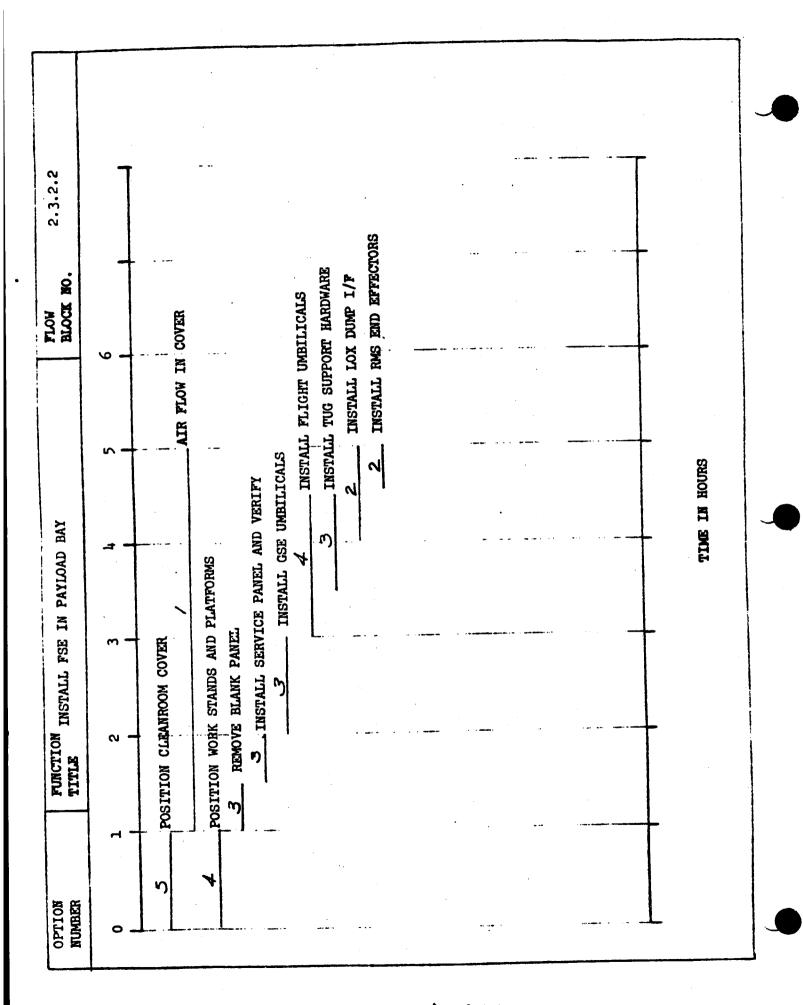
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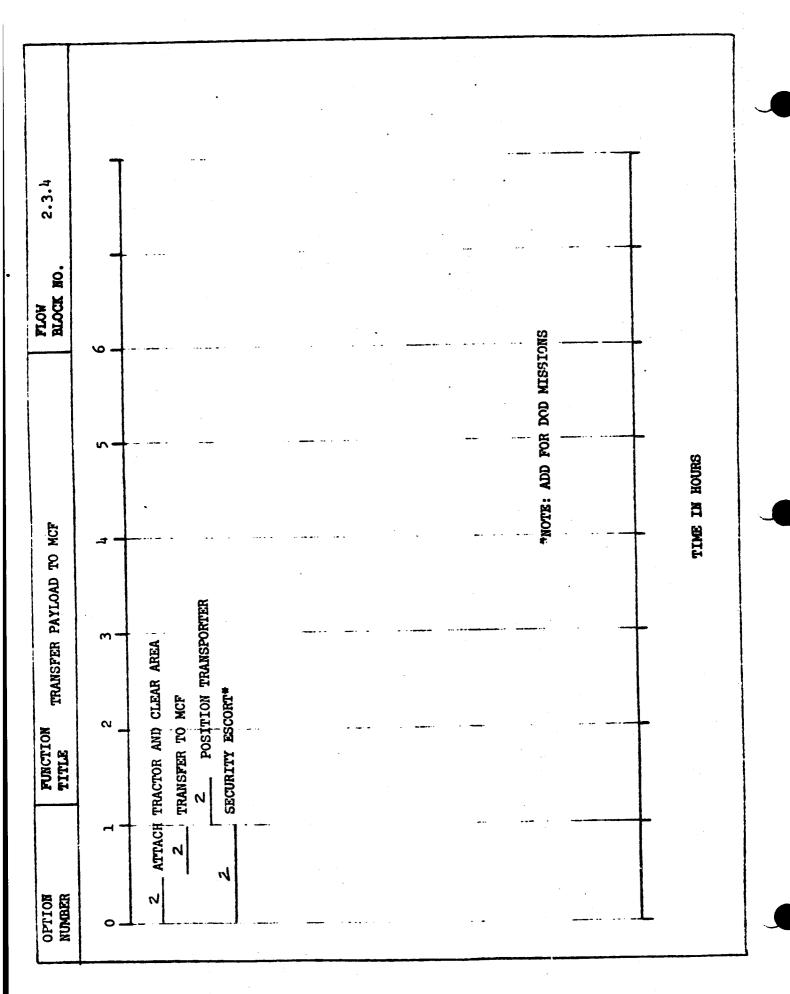
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	9 6		·								ADD FOR DOD MISSIONS				
	1			TI IN MCF AT ORBITER AREA	ING FSE	UNITOAD PSE					Note: Add F			TIME IN HOURS	
TRANSFER FSE TO MCF	3			POSITION TRANSPORT IN MCF AT ORBITER AREA	PREPS FOR UNLOADING FSE	9		- · #==			•			TIN	
	2	\$CORT#	REA TO MOF	CON TRANSPOR	3 PRE					<b></b>					
FUNCTION	1	SECURITY ESCORT*	TRANSPORT CLEAR AREA  2 TRANSPORT TO MCF	2 POSIT					•			. makes an Allender		:	,
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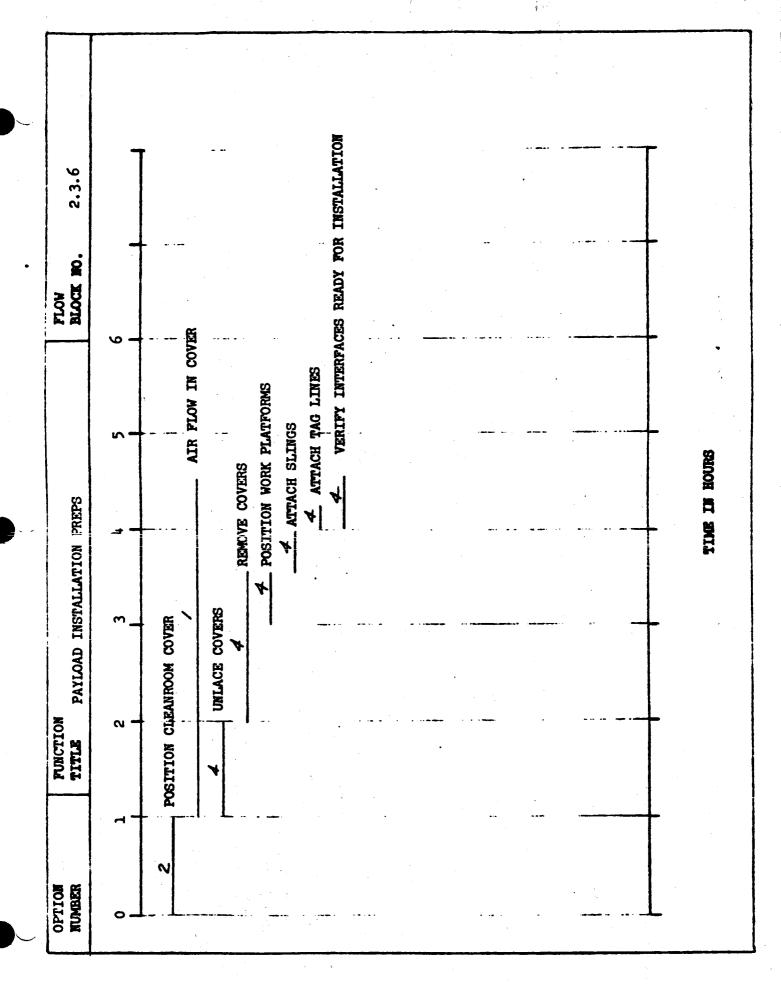


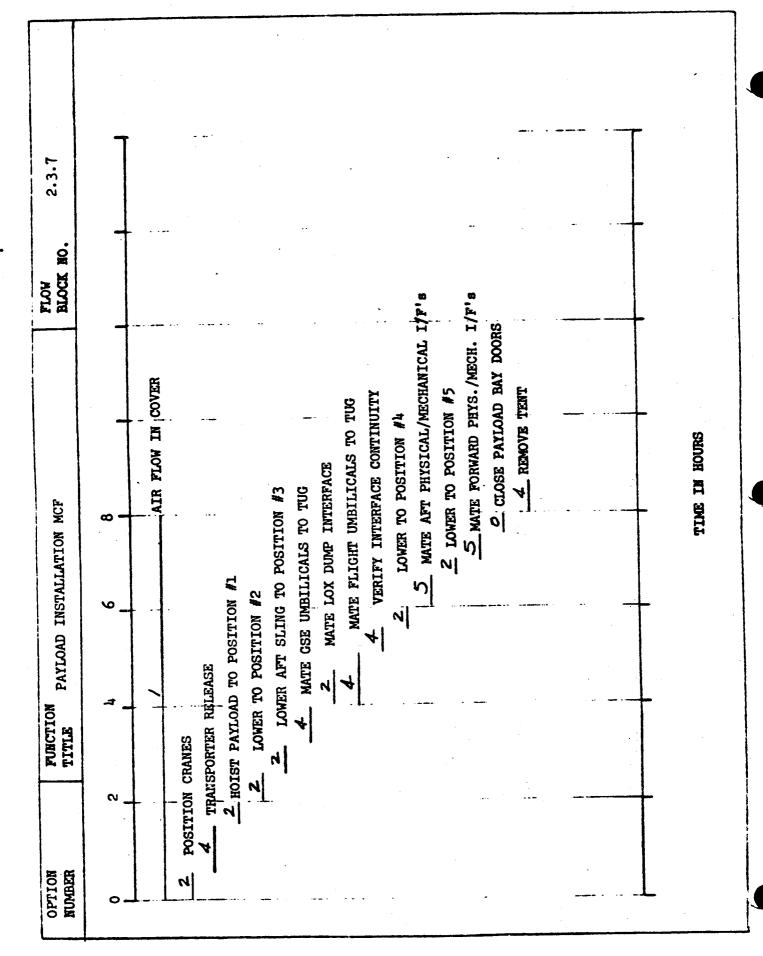
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INSTALL ESE IN CABIN (COMSEC)	Î	TRANSFER CREW AND COMSEC TO CABIN AREA	INSTALL COMSEC EQUIPMENT  2 VERIFY INTERFACE	CREW ECRESS	<b>8</b>	· .							Ē
NSTALL ESE	m <b>-</b>	AND COMSEC	STALL COMSE	4	•	••••••	·	•					
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Interfaces	_	UITY STANDS AND PLATFORMS	
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VERIFY		COJ MUIT	
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	~	VERIFY UNBILICAL CONTINUEY  WERIFY RMS CONTINUETY  REMOVE WORK	
FUNCTION		EN CIVER	
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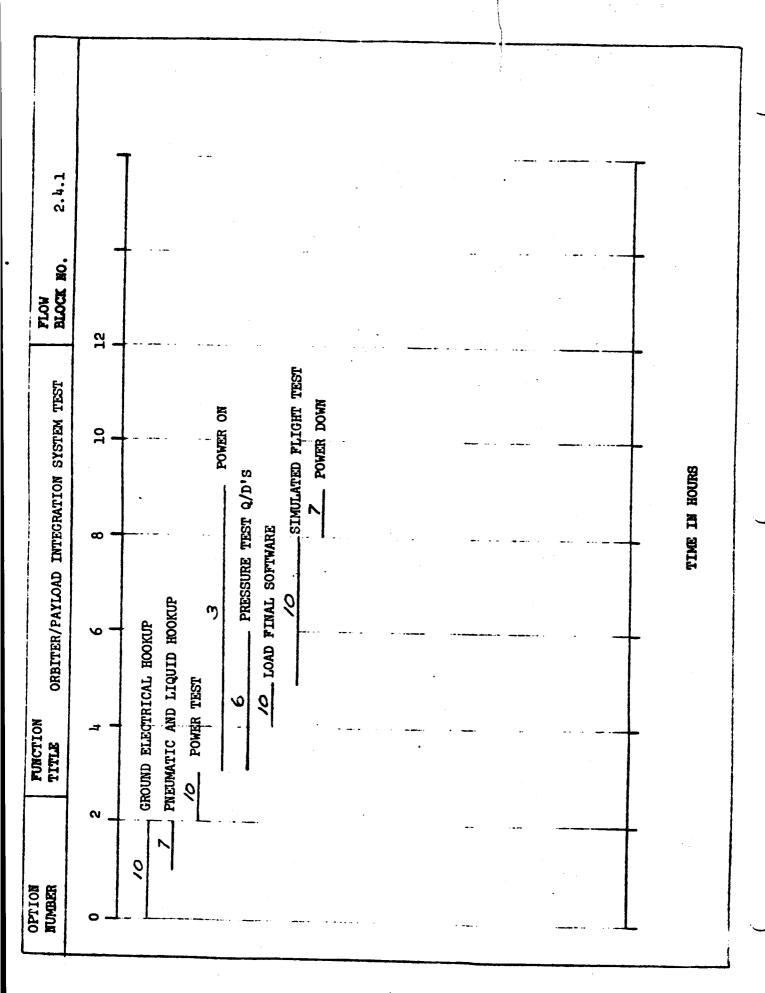


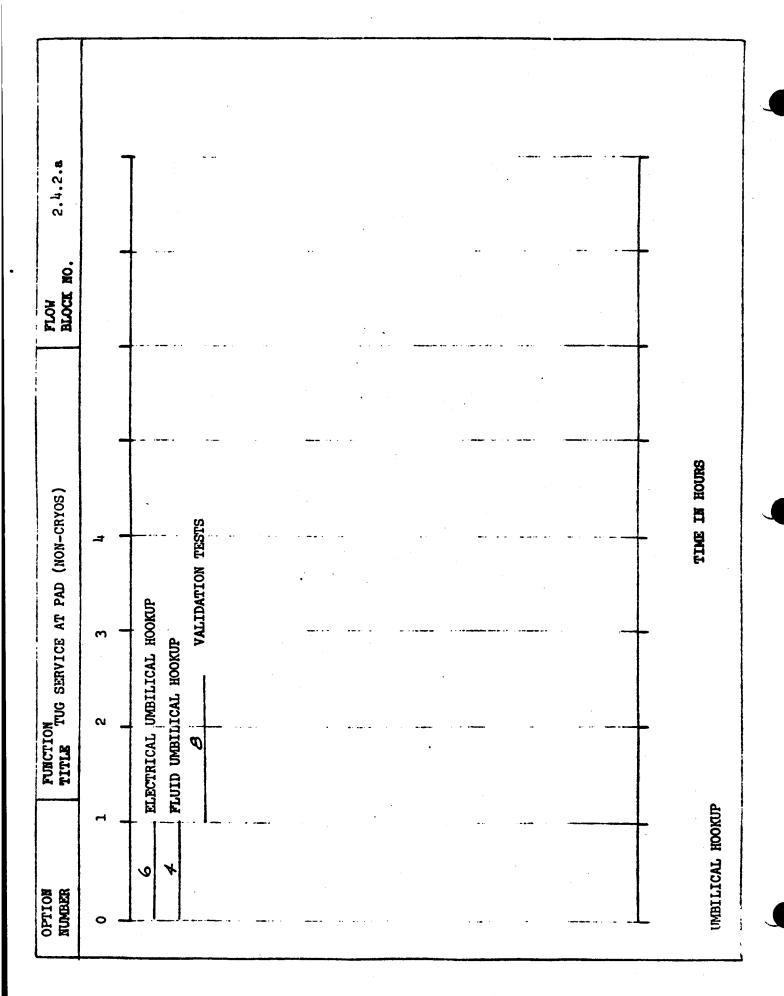


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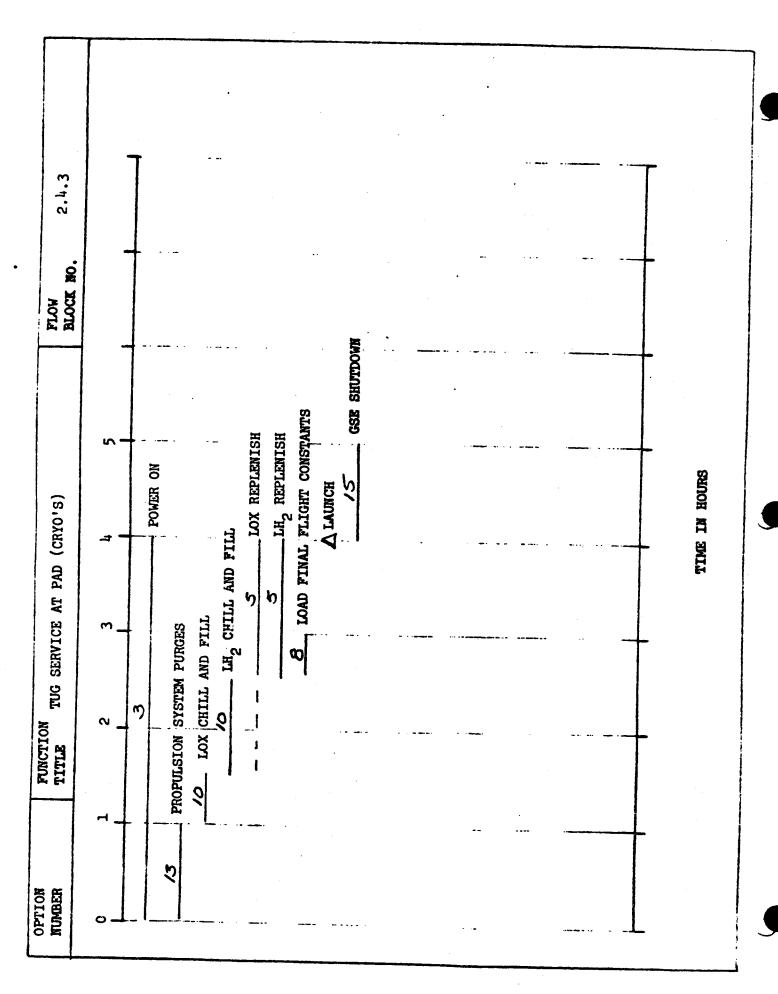
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	2.3.9			- •-	CABLES	<del></del>					-		
•	FLOW BLOCK NO.	12		HT INTERFACES ORBITER	CALS,	•		<del>-</del>		. •			
	FACES	10	70	(FUNCTION TEST) ORBITER FLIGHT INTERFACES  WALIDATE TUG SOFTWARE IN ORBITER PRESSIRE AND LEAK TEST OF OLDIS	ELECTRICAL SHUTDOWN  /O DISCONNECT GSE, UMBILICALS,		, <del></del>			100000000000000000000000000000000000000		-	
	PAYLOAD-TO-SHUITLE INTERFACES		ABLES, CONNECT UMBILICALS ON SOFTWARE	WCTION TEST) VALIDATE TUG PRESSIRE AND	10 ELECTRICA	•.						•	TIME IN HOURS
	!	9-	CABLES, CONNIER ON SER ON SER ON SER ON SER SOFTWARE	VALIDATE 7	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	······································							
	FION VERIFY	7	SET UP GSE, CONNECT CA	19			MA CORPORATE	·					
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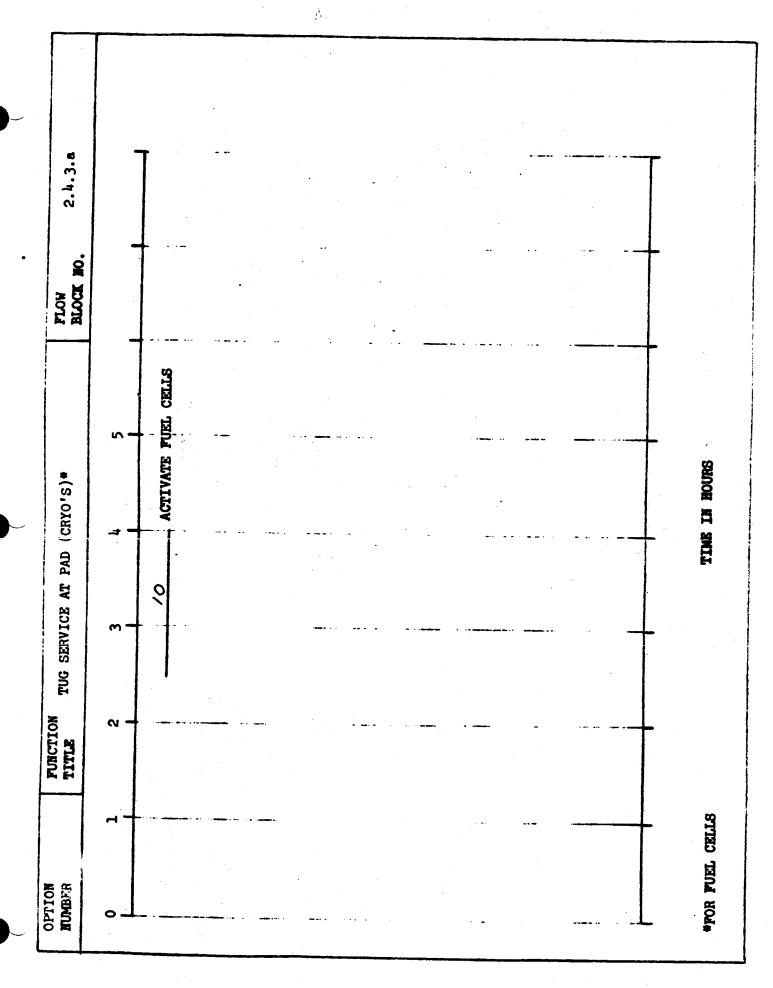
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2.4.2.b	_							na a main arthréin a namh	T
FLOW BLOCK NO.							. <u>.</u>	<u></u>	
	5			CHECKS					
D (NON-CRYO)	.a-		POWER ON	PROPULSION SYSTEM CHECKS	· · · · · · · · · · · · · · · · · · ·				TIME IN HOURS
TUG SERVICE AT PAD (NON-CRYO)	· ~	· · · · · ·	DESTINA	THEOREM !	···	<del></del> .			
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TITLE	-4	POWER TEST  S POWER UP	12					elektrin mirrikara gengankansanga	
NUMBER	0	9			en en en en en en en en en en en en en e			· · · · · · · · · · · · · · · · · · ·	





OPTION	FUNCTION	TUG SERVICE	3 AT PAD (CRYO'S)*	370'5)*	FLOW BLOCK NO.	2.4.3.b	
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		ТПП 9		HEAT EXCHANGER AND FILL  6 LOAD AND TOP-OFF COLD He BOTTLES	COLD He BOTTLES		
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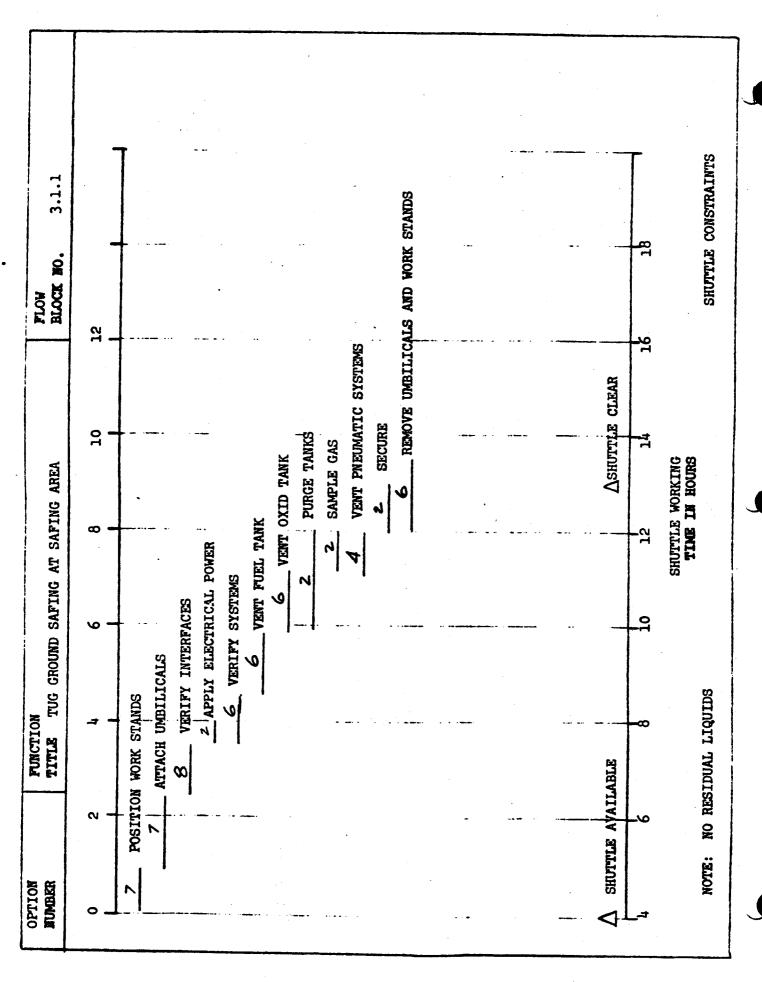
TITLE  1 2 3 4 4 5  POSITION WORK PLATFORMS  TRANSLATE CHANGEOUT UNIT TO PAYLOAD BAY  4 ATTACH CHANGEOUT UNIT TO PAYLOAD BAY  5 RELEASE MECHANICAL STRUCTURAL INTERFACES  4 DEMATE GEE INTERFACE UMBILICALS  4 DEMATE FLIGHT INTERFACE UMBILICALS  5 TRANSLATE PAYLOAD TO POSITION #1  6 COVER PAY  6 ATTACH  7 ATTACH  8 ATTACH  9 ATTACH  10 PAYLOAD  11 2 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

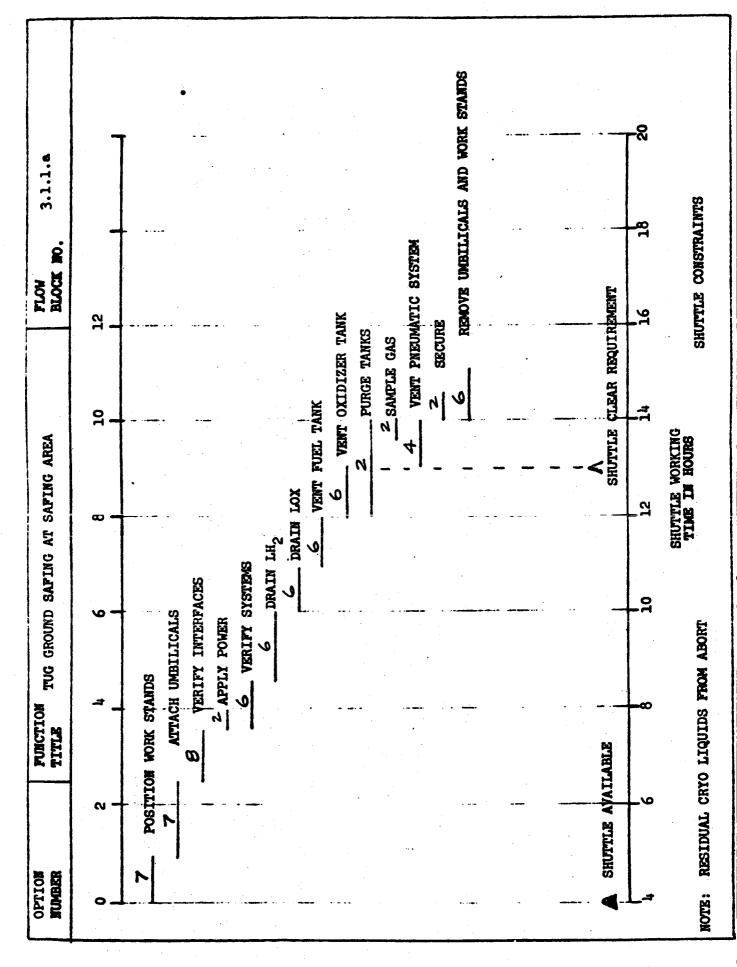
D-224

2.4.6				-	<del>-</del>		
FLOW BLOCK NO.			• ••••		/ REMOVAL		
eps (PAD)					VERIFY INTERFACES READY FOR INSTALLATION	•• •	
INSTALLATION OR REMOVAL PREPS (PAD)			IND SECURE	M AIRFLOW	S READY FOR	PLATFORMS	TIME IN HOURS
TALLATION OF			BAY DOORS A	PAYLOAD ROOM AIRFLOW	FY INTERFACE	READY WORK PLATFORMS	TING
FUNCTION PAYLOAD INS	m <del>-</del>	ANBOOM	OPEN PAYLOAD BAY DOORS AND SECURE		VERI	4	
FUNCTION	7	MOGUNATION CLEANBOOM	0	0		- ·	
OPTION NUMBER		0					
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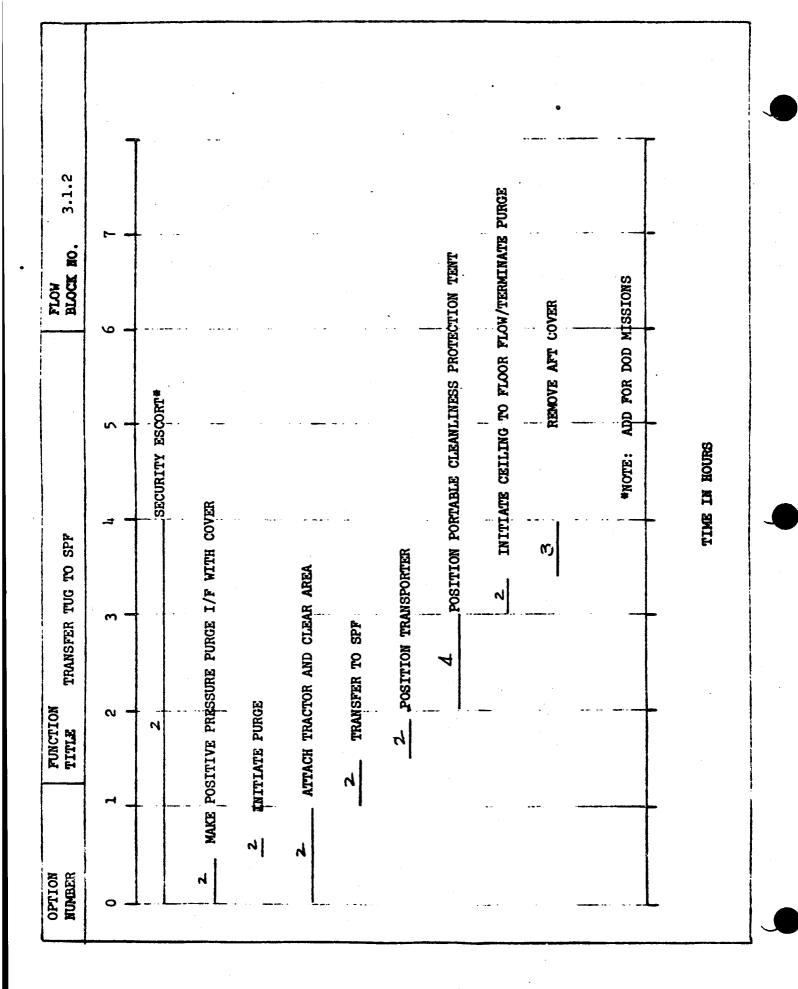
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2.4.7	·						CELLION #1			**************************************			
BLOCK NO.	1				•		VERIFY PHYSICAL I/F'S  RELEASE PAYLOAD AND TRANSLATE CHANGEOUT UNIT TO POSITION	angenera d'a					
	-			-	ر <u>ه</u> .	MATE FORWARD PHYSICAL/MECHANICAL I/F'S	ANSLATE CHANG		·				
ON (PAD)	<b>&amp;</b>	rion #3)		NUITY	INSTALLATION POSITION	PHYSICAL/MEC	VERIFY PHYSICAL I/F'S  RELEASE PAYLOAD AND TR				···	-	TING IN HOURS
AD INSTALLATION (PAD)	9 -	DAD BAY (POSITION	NO TUG INTERFACE	i NTE FLIGHT UMBILICALS VERIFY INTERFACE CONTINUITY	E TO INSTALLA	MATE FORWARD	S RELEASE P	<del></del>	requires arches				
TITLE PAYLOAD	.a. •	TRANSLATE PAYLOAD TO PAYLOAD BAY	MATE GSE UMBILICALS TO TUG  2 MATE LOX DUMP INTERFACE	MATE FLIGHT UMBILICALS   VERIFY INTERFACE CO	TRANSLATE TO	MATE MATE							
TITLE	2 -	TRANSLATE PA	4 MATE GSI	4	<b>-</b> .				. 411	. <b></b> .			
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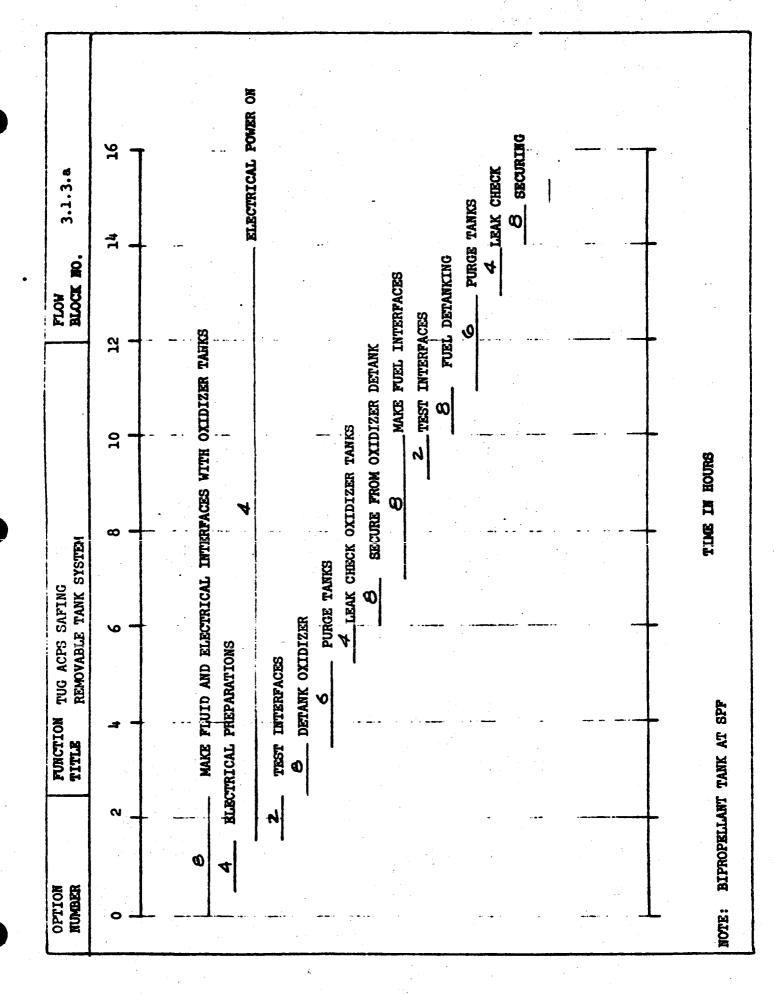
TIME IN HOURS

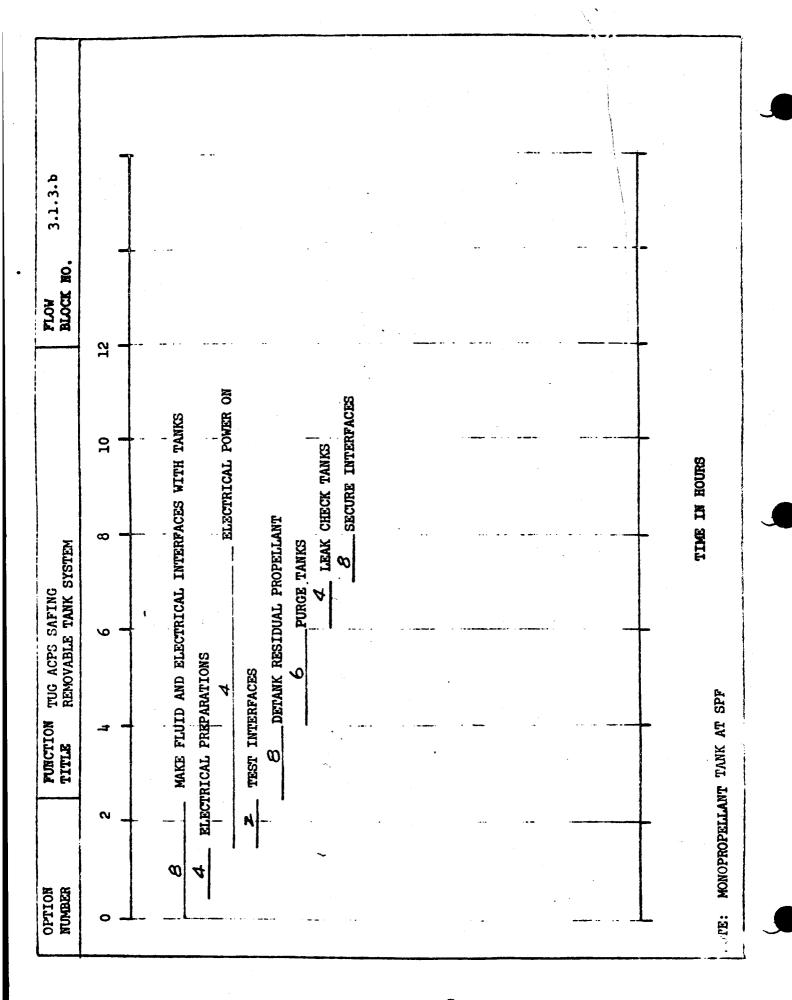


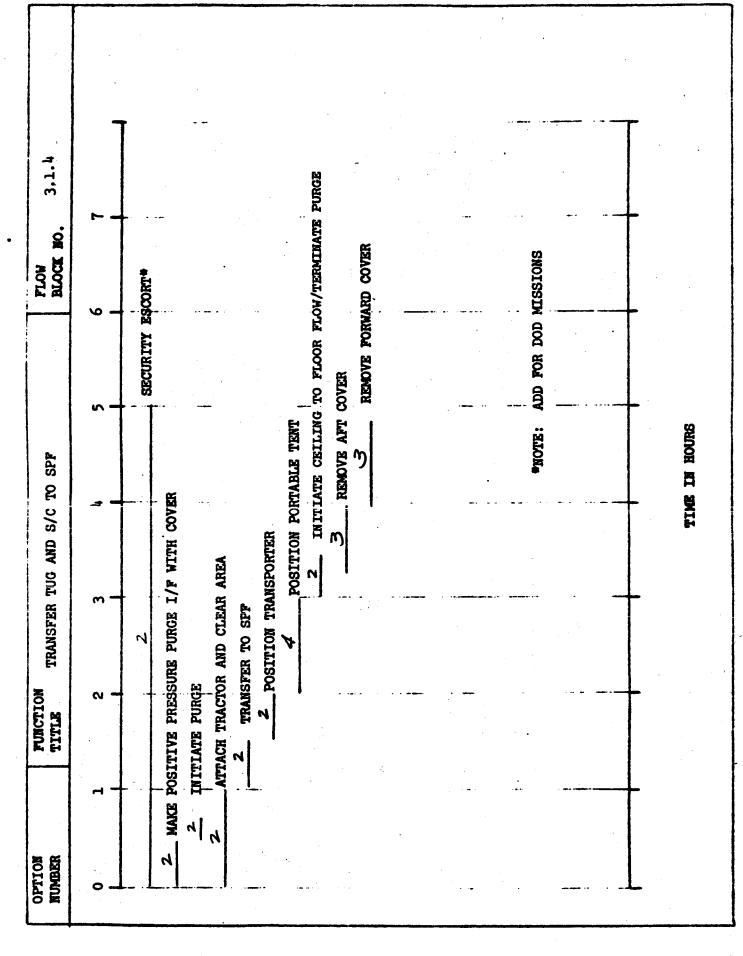


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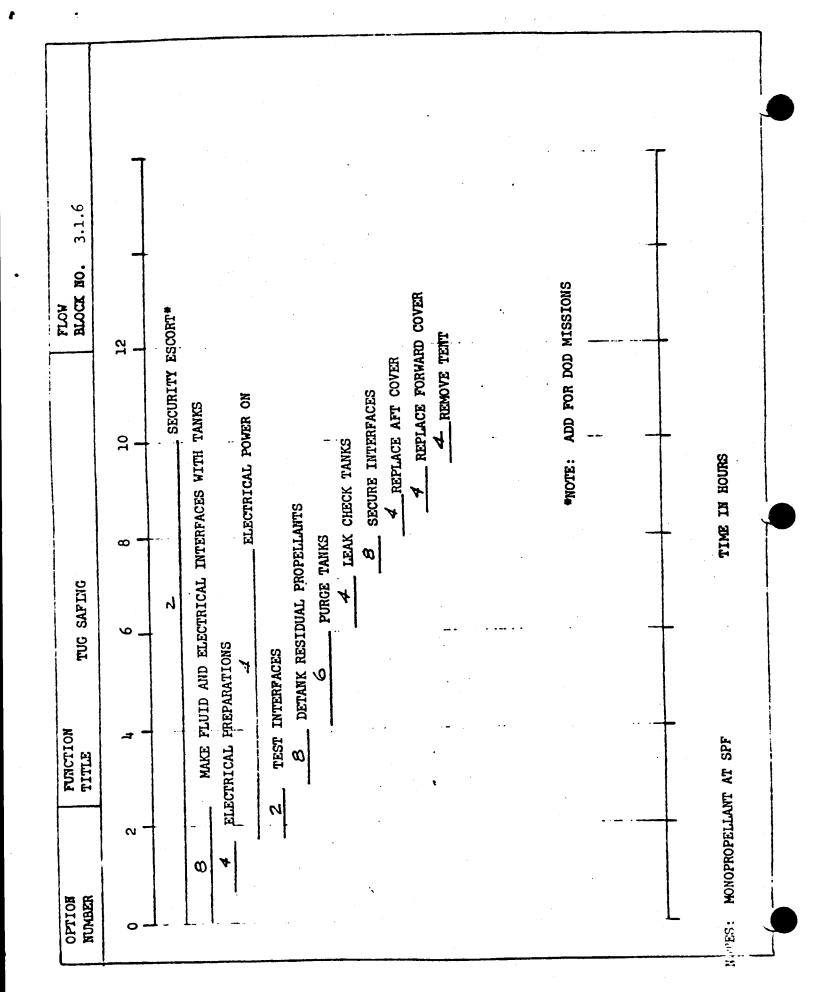


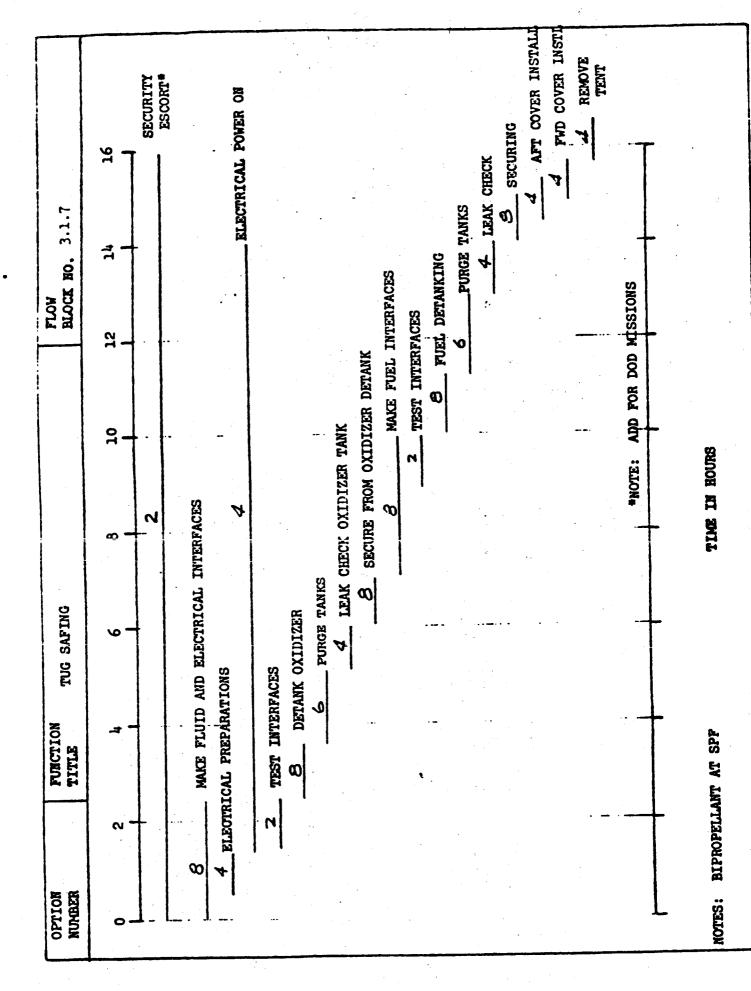


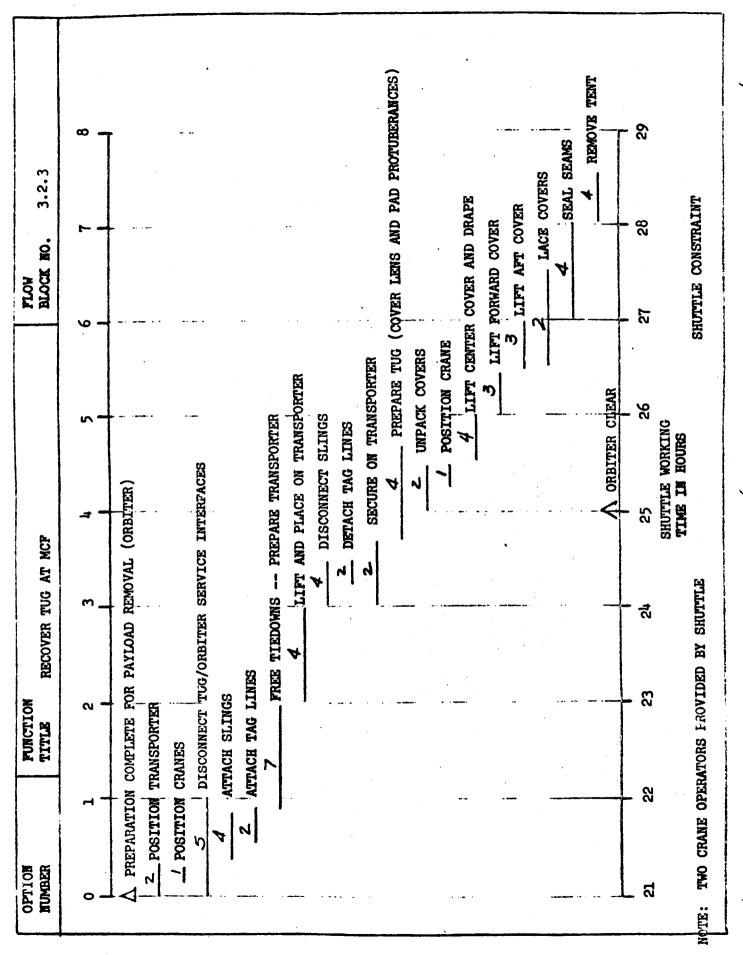


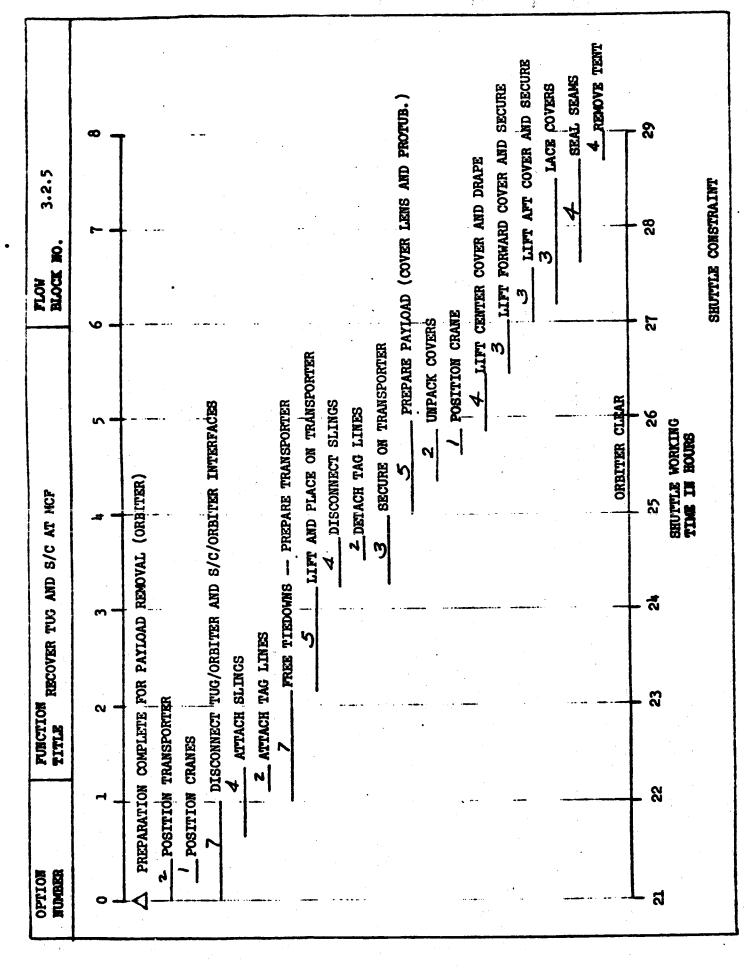


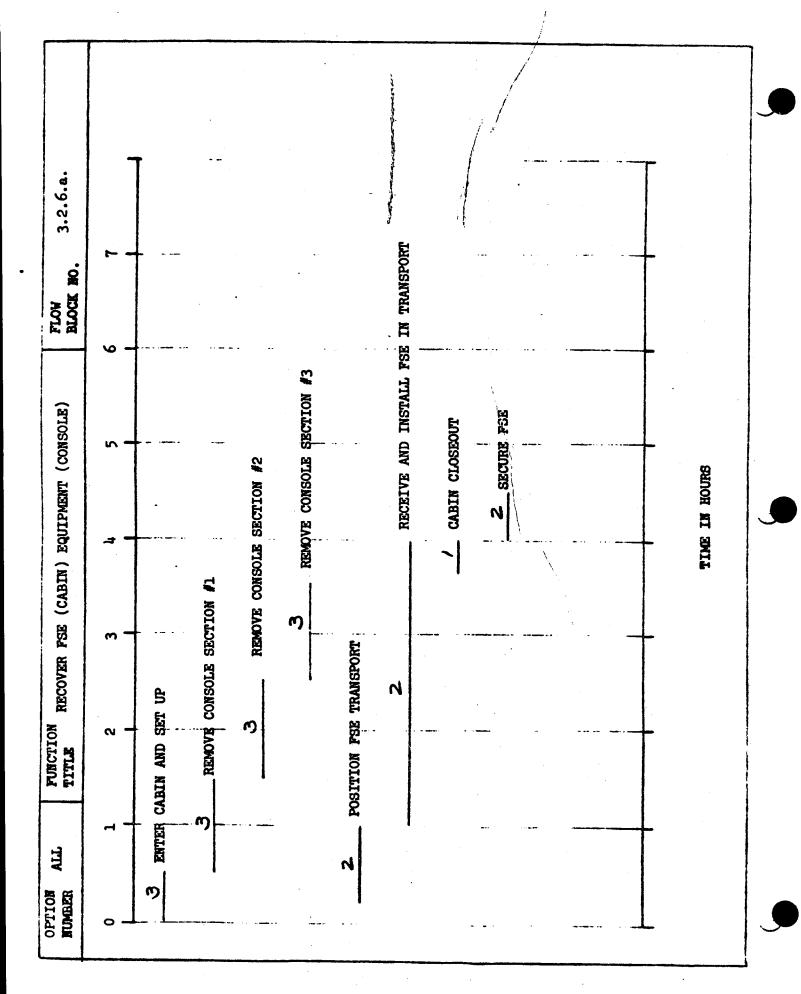
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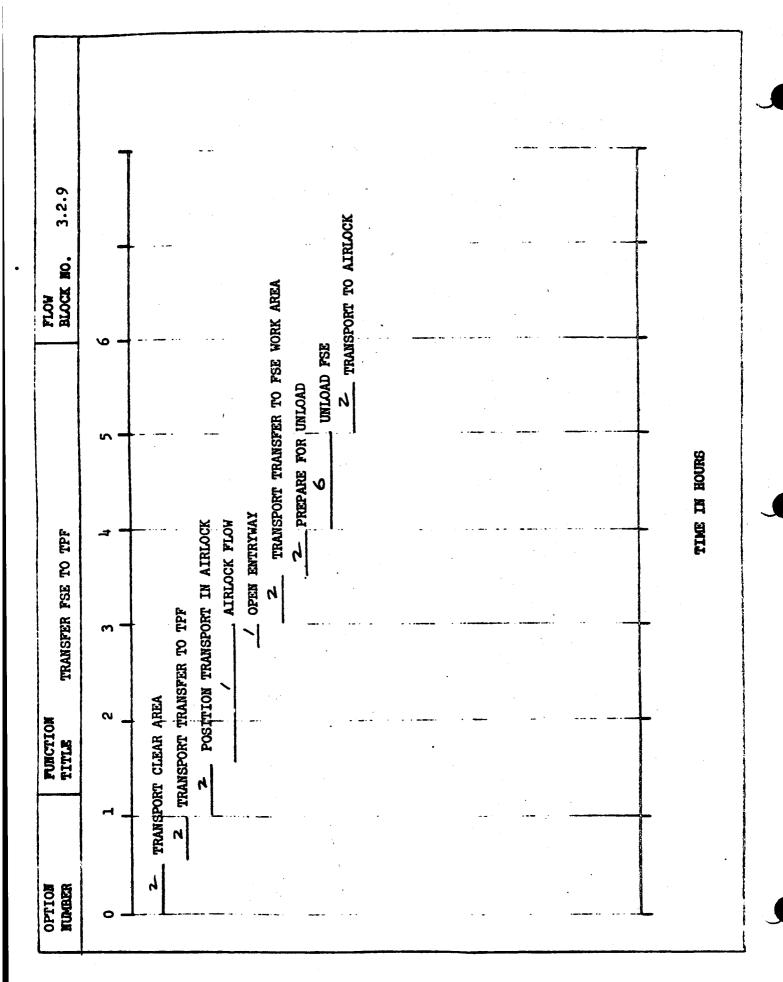




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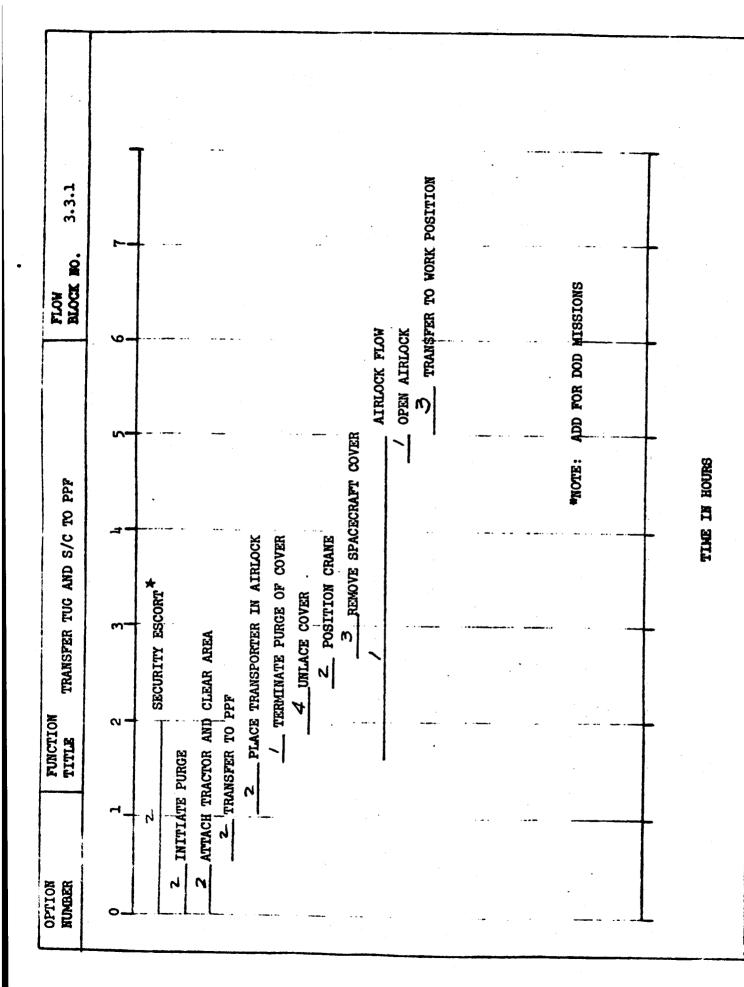
ж ио.	7	- · · · ·				<b>EDWARE</b>	FSE IN TRANSPORT REMOVE WORKSTANDS	•	• • •	•		- -	
PMENT BLOCK	5 6		ILICALS	. (9	MP INTERFACE EFFECTORS	REMOYE TUG SUPPORT HARDWARE	RECEIVE AND STOW FSE IN TRANSPORT  SECURE FSE  REMOVE WORKSTAND		**************************************				88
3 (PAYLOAD BAY) EQUIPMENT	.a =	PLATFORMS	ION FSE TRANSPORT REMOVE GSE AND FLIGHT UMBILICALS	E SERVICE PANEL (T-26)	REMOVE LOX DUMP INTERFACE REMOVE RMS END EFFECTORS	A	*	·	· · · · · · · · · · · · · · · · · · ·	• • • • • • • • • • • • • • • • • • • •			TIME IN HOURS
TITLE RECOVER FSE	- s	POSITION WORKSTANDS AND	POSITION FSE	3	7						:		
NUMBER ALL TO	- C	4 POSTE	]			· · · ·							

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3.2.10						· /				OCK				•			-		
PLOW BLOCK NO.	9 -			· ·				DING	eg.	TRANSPORT TO AIRLOCK	-			MISSIONS			-		
	ν-		<b>-</b> •••				SE WORK AREA	PREPARATION FOR UNLOADING	UNITOAD FSE	Z TRAN			1	. ADD FOR DOD MISSIONS	•				
idd	<b>≟</b> =			NOCK .	MOTA X	OPEN ENTRYIAY	TRANSPORT TO PSE WORK AREA	2 PREPARA	9				, -	*NOTE:	· ·				TIME IN HOURS
TRANSPER PSE TO PPF	m-	SECURITY ESCORT		I TO PPF  HSPORT IN AIRLOCK	. ~	OPEN E	2	***	<b></b>	·	<del></del>	·	•			•	. · · · · ·		
TITLE TRAN	8 -	SECURIT	TRANSPORT TO CLEAR AREA	TRANSPORT TRANSPER TO PPF  Z POSITION TRANSPORT	`			•		•		•	• • • • • •				<del></del>		
	1	- 1	TRANSPORT I	TRANS		•• •• ••						3		• • • • • • • • • • • • • • • • • • •		· · ·		-	
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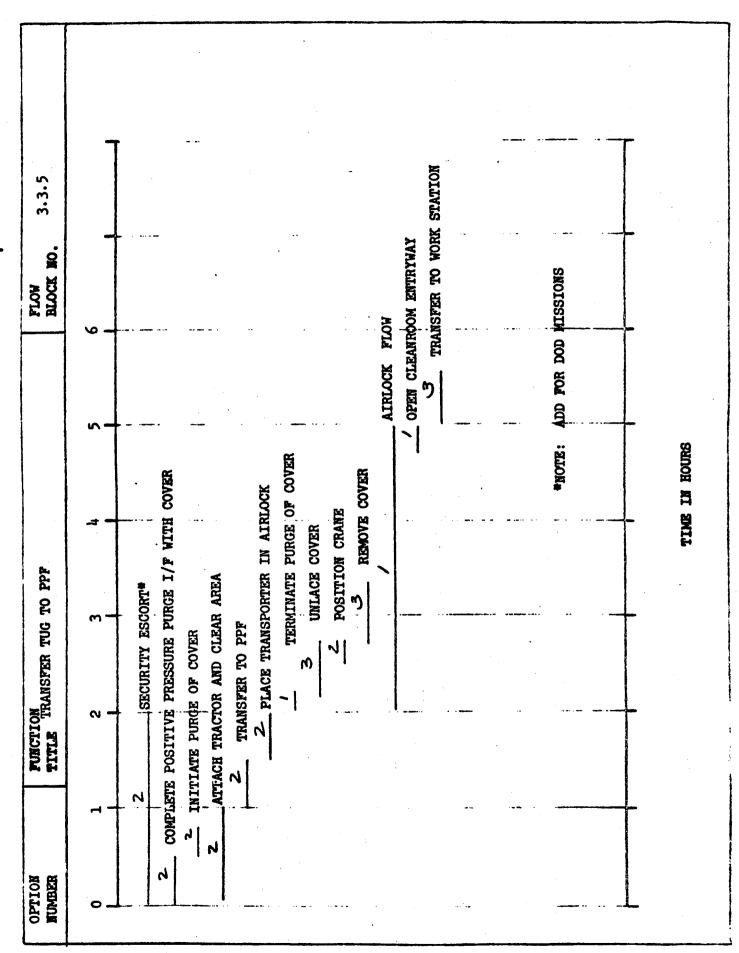
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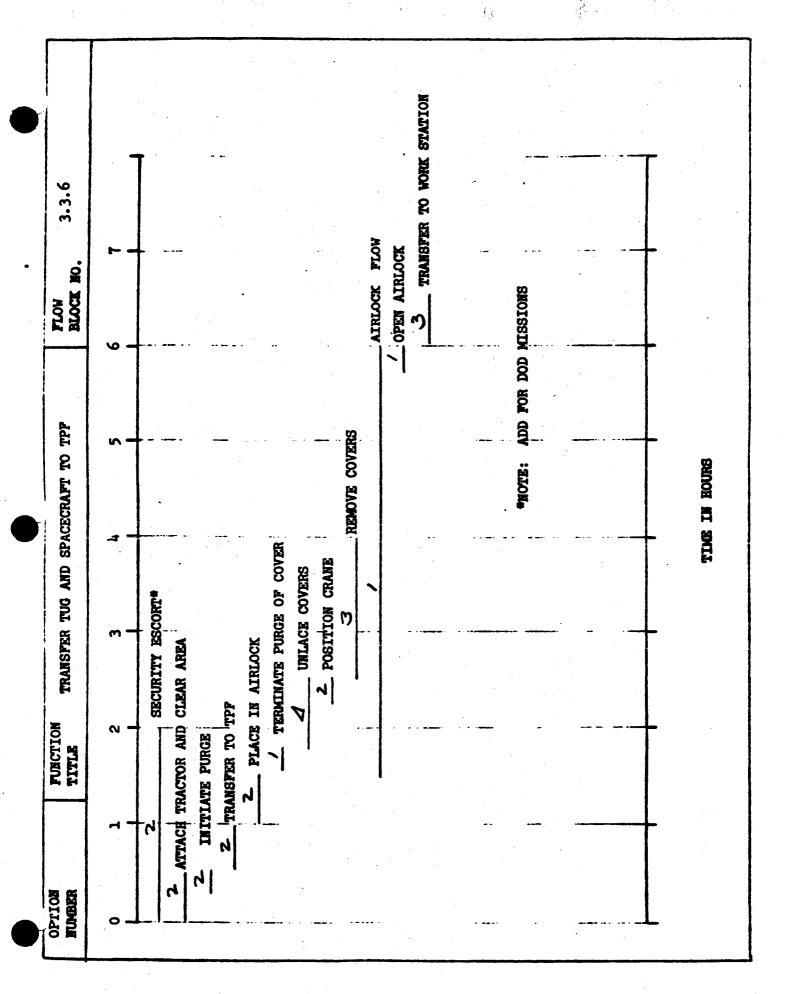
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2 MAK	E PURGE	INTERFAC	E AND INT.	MAKE PURGE INTERFACE AND INITIATE PURGE	38					
2	ATTACH	I TRACTOR	ATTACH TRACTOR AND CLEAR	R AREA					-	
	N	TRANSFE	TRANSFER TO TPF	FER TO TPF PLACE TRANSPORTER IN AIRLOCK	AIRLOCK	. ما				
	•	1	TERMINATE	te purce						
			4 0	UNLACE COVERS	COVERS					
	•		. 1	S BEWOVE A	CKANE	COVER	ON CRAME PERMOVE APP COVER AND STORE		••	
				ł	REMO	VE FORW	REMOVE FORWARD COVER AND STORE	AND STORE		
		·•			"	3 REMO	REMOVE CENTER COVER AND STORE	COVER AND S	TORE	
								AIRLOCK FLOW	FLOW	
		e delament			• •		1	OPEN AIRLOCK	TOCK	
		*			. ·			り は 対	TRANSFER TO ROOM	TO LIMITED ACCESS
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				-	TIME IN HOURS	HOURS				

NUMBER	TITLE	1	RECOVER SPACECRAFT EQUIPMENT	UIPMENT		BLOCK NO.	3.3.4	
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3 POSIT	POSITION END WORK STAND	K STAND	<u>.</u>		·			
2 POSIT	POSITION SIDE WORK STAND	RK STAND	•			<del>-</del>		
7		REMOVE SPACECRAFT	T EQUIPMENT			· · ·	- <del></del>	•
	4	REMOVE WORK	STANDS			•		
		TRAN	TRANSFER TUG TO AIRLOCK	A IRLOCK				•
		/ OPEN	CLEANROOM ENTRYWAY	FERYWAY				
				AIRLOCK FLOW		•		
	•	N	POSITION CRANE	M CRANE	MANO			
• ••	•		T JQU	ACE FURNALLY				
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No. 3.3.7									MOTA X		INSTALL FORWARD TUG COVER		 			er eine Bereichte (des des des des des des des des des des
AFT BLOCK NO.	5 6				- E	REMOVE SPACECRAFT EQUIPMENT	REMOVE WORK STANDS	TRANSFER TUG TO AIRLOCK	OPEN CLEANROOM ENTRIWAI / AIRLO CK FLOW	ION CRA	THSTALL FOR	  	 		TIME IN HOURS	AST - OFFICE AST PROFESSIONAL PROFESSIONAL STATES AND CONTRACTOR AND ASSESSION AND ASSESSION AND ASSESSION AND ASSESSION ASSESSION AND ASSESSION A
DEMATE TUG AND SPACECRAFT	3 4	STAND	ATTACH SPACECRAFT SLING(S)		DEMATE SPACECRAFT AND TUG	Z REMOVE	4			· ·			 		TOTAL	
OPTION FUNCTION NUMBER TITLE	1 2	POSITION END WORK STAND	3 ATTACH SPACE	POSITION CRANE	-	-					-	 -			· ·	

2 POSÍTICIA END WORK STAND 2 POSÍTICIA SIDE WORK STAND 3 KENOVE SPÁNCHAPI EQUIDACENTE (AND TWO MES FOR COMERC AT WITE)*	MUMBER	FITLE	RECOVER	SPACECRAFT EQUIPMENT	ULPMENT		FLOW BLOCK NO.	3.3.8	
POSÍTION EIDE WORK STAND  S REMOYE SPACECRAFT EQUIPMENT"  (ADD TWO MEN FOR COMSIEC AT	o <b>–</b>			5		<b>~</b>		·	
POSÍTION SIDE WORK STAND  (ADD TWO MEN FOR COMSEC AT  (ADD TWO MEN FOR COMSEC AT  TIME IN HO	1	POSTITION KND WO	 RK STAND			•		·.	
KEMOVE SPACIECRAFT RQUITPMENT!  (ADD TWO MEN FOR COMSEC AT	. 1	POSTTION SIDE W	ORK STAND					, , , , , , , , , , , , , , , , , , ,	•
BBC AT		•	OVE SPACECRA	FT RQUIPMENT				,	
	1. Na <b>22</b>		(ADD TW	O MEN FOR COM	BEC AT	*-			
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		•													STATION					
3.3.9	7	-			-						-	IORE	FLOW	FRYWAY	Transfer to work station		•		• ·	
BLOCK IN	9		<u>.</u>			•				RE	COVER AND STORE	REMOVE CENTER COVER AND STORE	AIRLOCK FLOW	OPEN ENTRYWAY	m	<u> </u>			*.	
	5		<del></del>	-	-			ស្ព	-	C REMOVE AFT COVER AND STORE	REMOVE FORWARD COVER AND STORE	G REMOVE CE	,		***************************************	<u></u> -		ADD FOR DOD MISSIONS	TIME IN HOURS	
SFER TUG TO PPF	π_	ESCORT	NITIATE PURGE	LEAR AREA	i	AIRLOCK	TERMINATE COVER PURGE	UNLACE COVERS	2 POSITION CRANE	C REMOVE A	ŋ			· · ·				"NOTE: ADD FOR D	Tide	
TITLE TRANSFER	∾_	BECURITY ESCORT	MAKE PURGE INTERPACE AND INITIATE PURGE	ATTACH TRACTOR AND CLEAR	TRANSFER TO PPF	2 PLACE IN ATRIOCK	L TERMIN	4	4	•					• • • • • • • • • • • • • • • • • • • •				-	
	н.	2	MAKE PURG	2 AFF	7		<del></del>						•		•••				•• •	

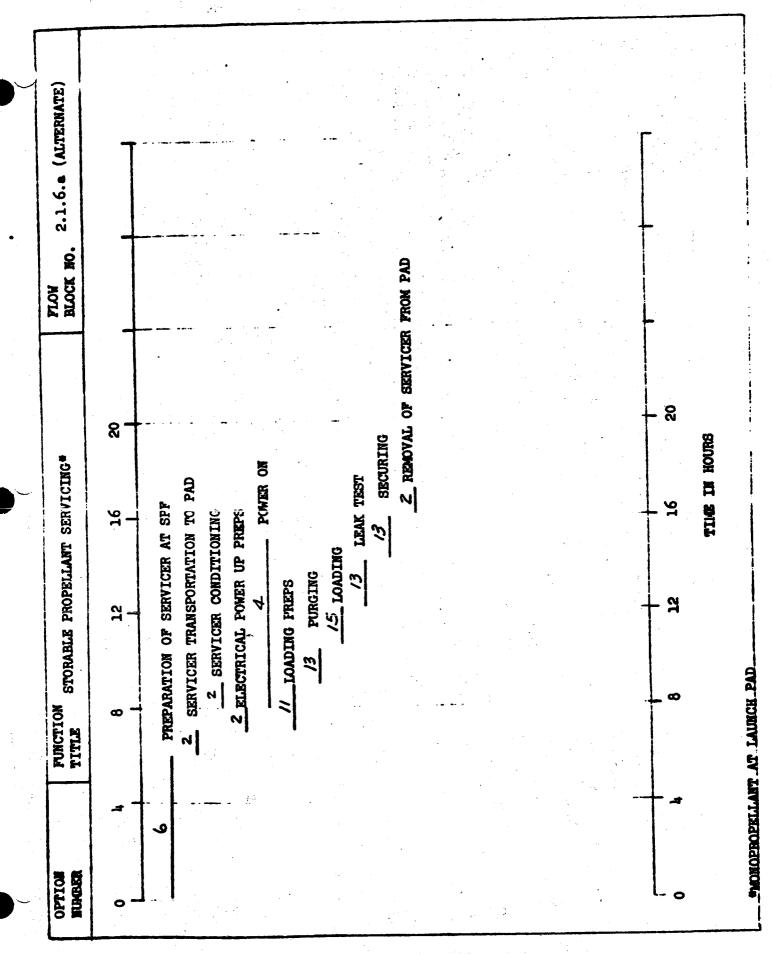
. 3
SECURITY ESCORT
ATTACH TRACTOR AND CLEAR AREA  INITIATE PURGE
FER TO PPF PLACE IN AIRLOCK
TERMINATE COVER PURGE
*NOTE:
-

ALTERNATE TIMELINES

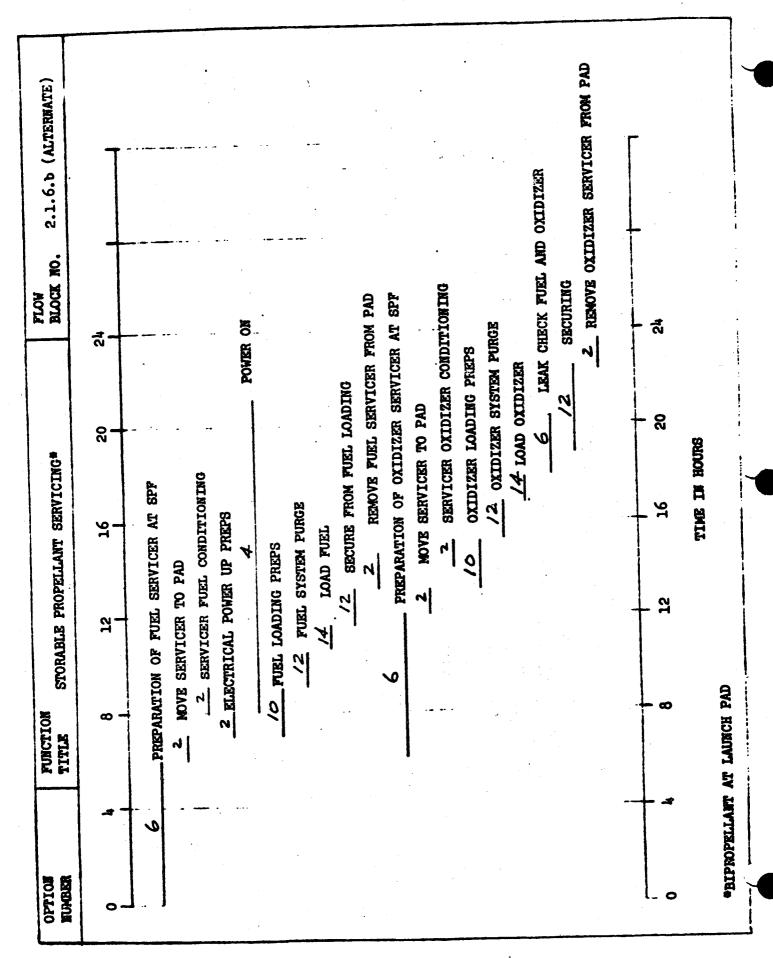
FOR THE

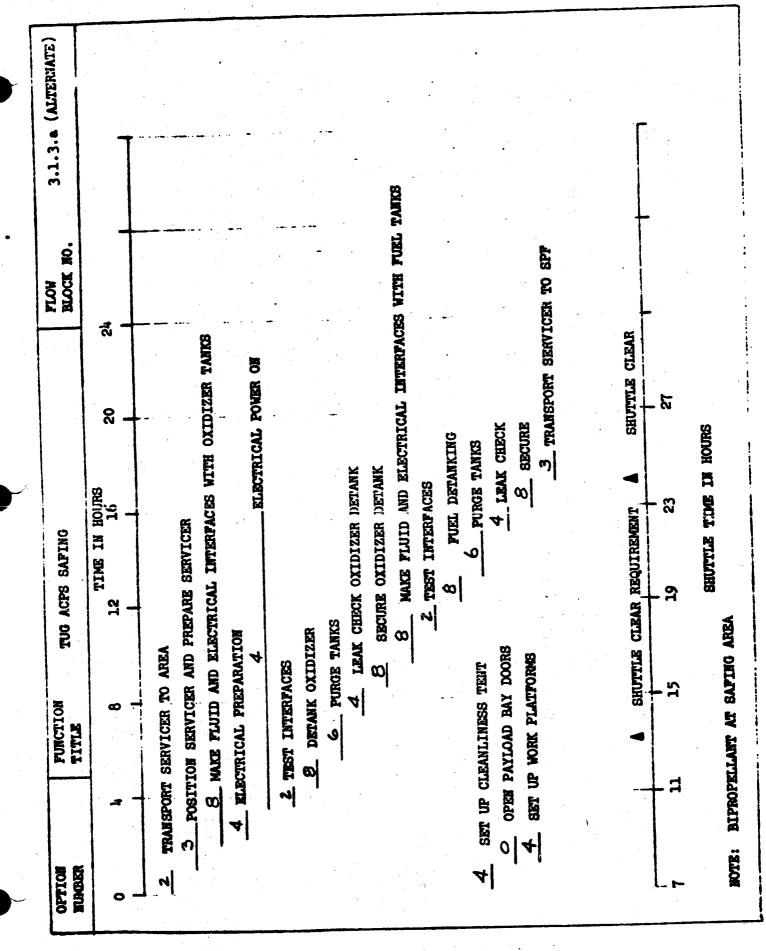
MDAC

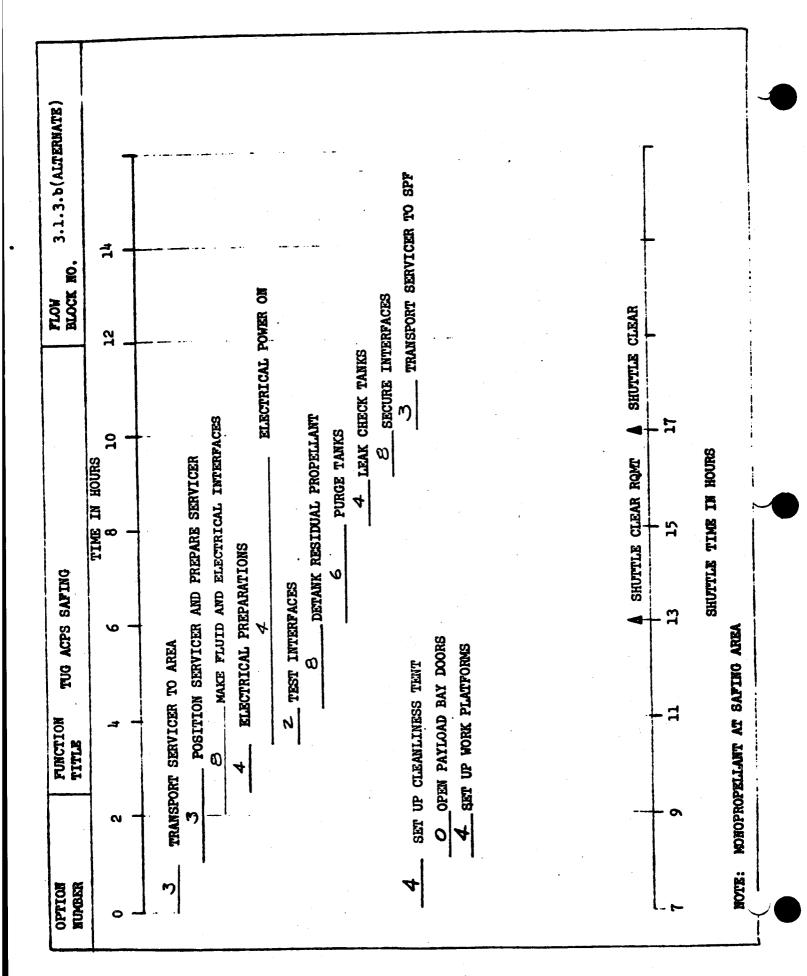
CRYOGENIC TUG GROUND OPERATIONS

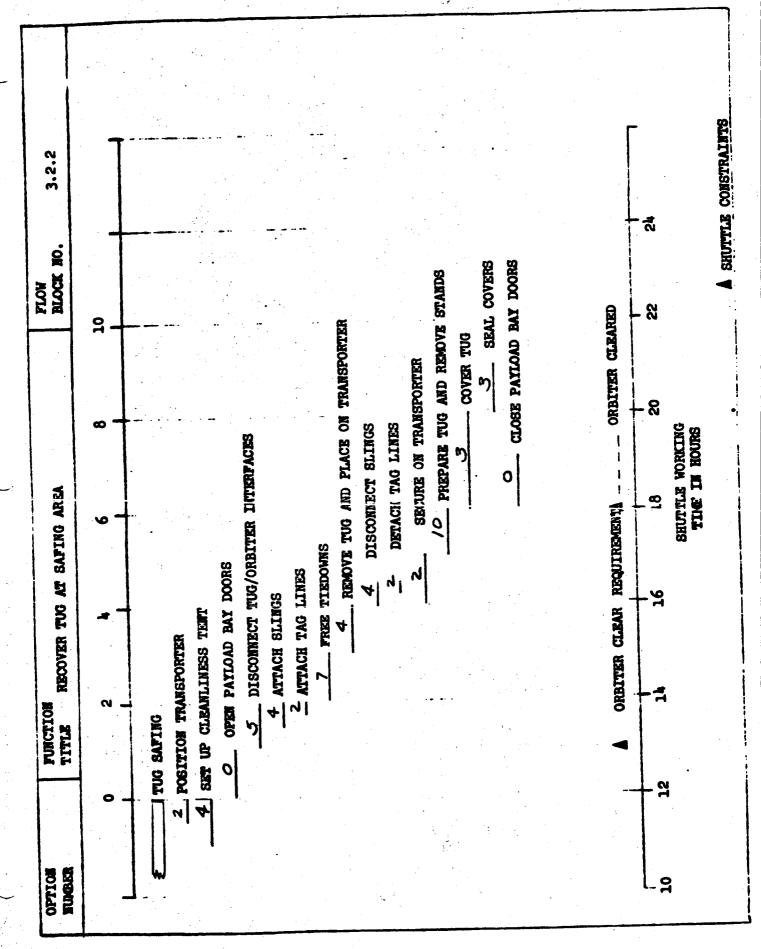


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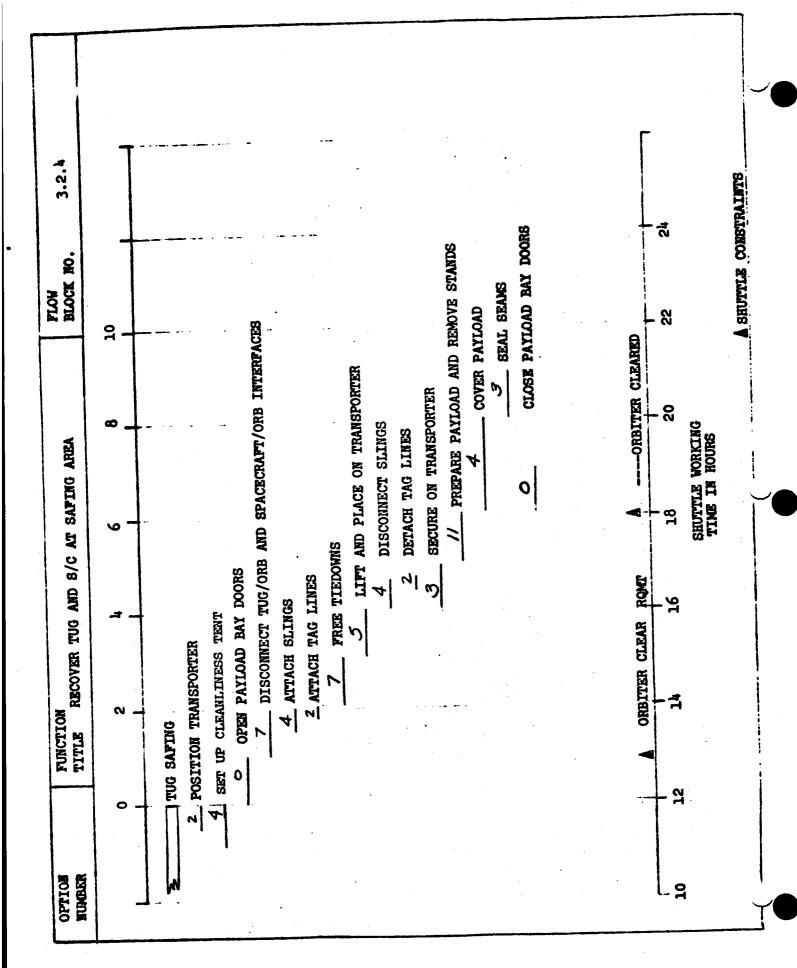








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11.10 Appendix E GSE Description Sheets

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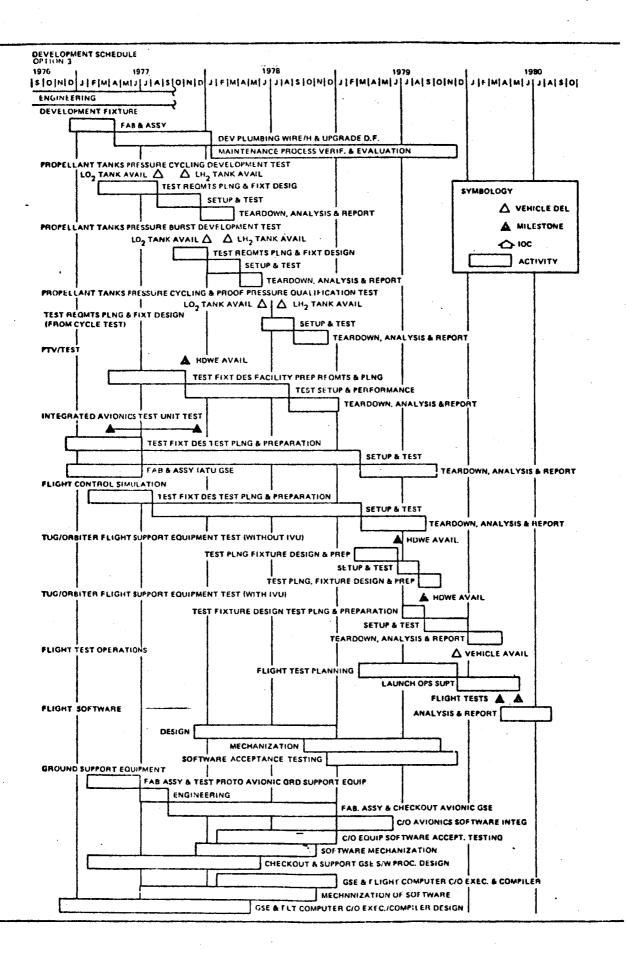
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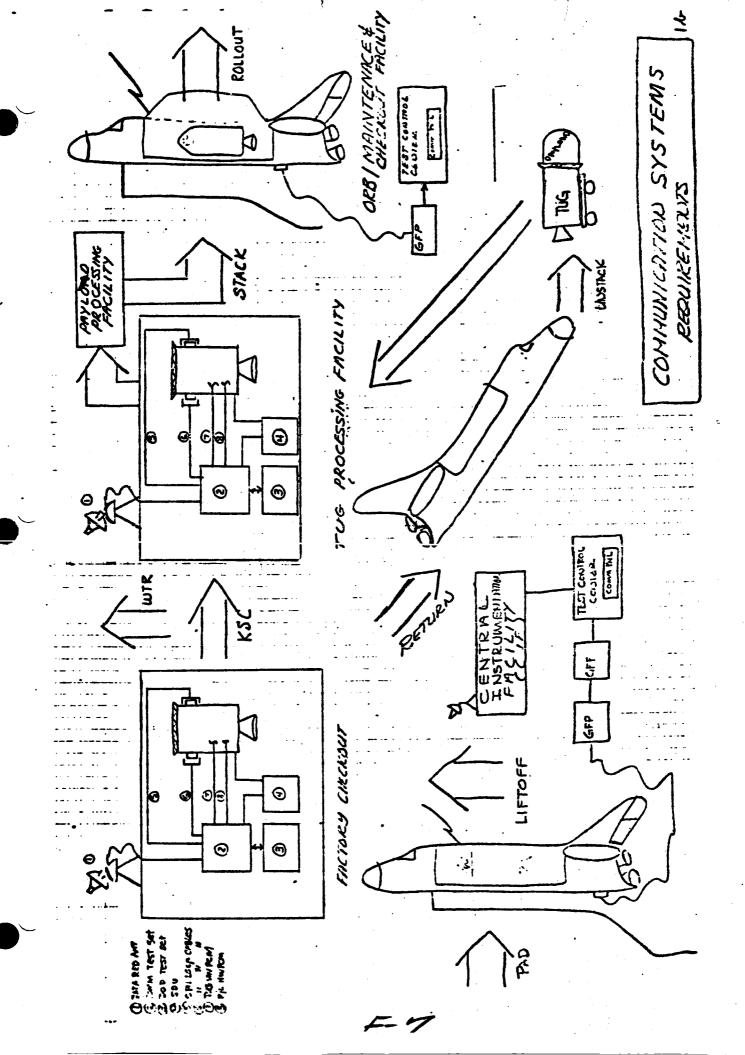
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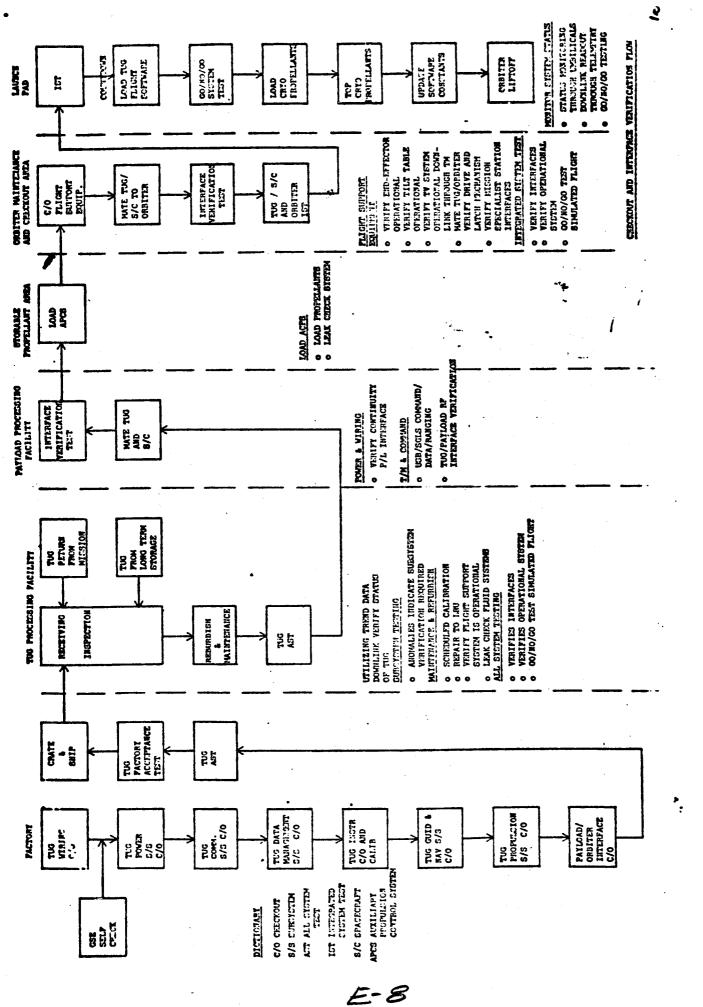
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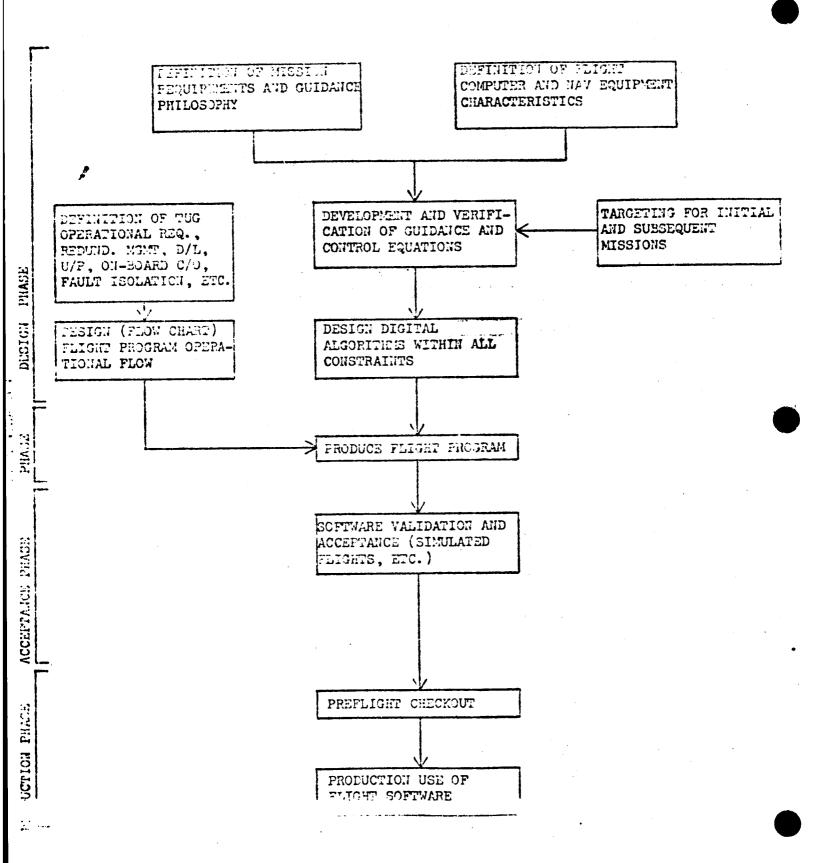




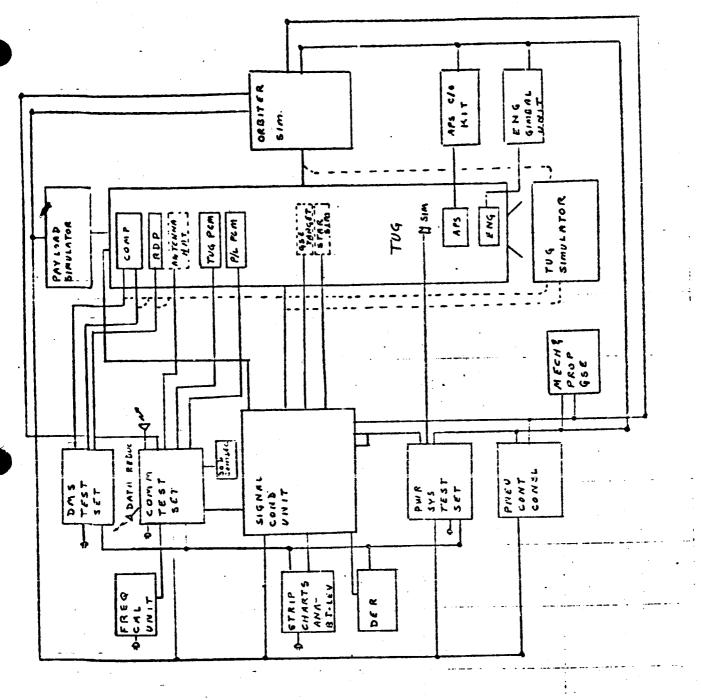


COUVERS FLOW CHARTH 14-PROGRAM CODE AND COTTELL VALIDATE PEST COFFWARE NO HIGH LEVEL LANGUAGE CHE CHE MAN THE THE (TRUE PLAN COART) CHECKCUT PRACTICES CHECKOUT TROTTER PRODUCET ST US FLIGHT COMPUTER C/O EXEC DEPTHITTION OF GON AND TUG GENERALE FLIGHT COMPUTER PRODUCE PLIGHT COMPUTER DEFINITION OF HIGH LEVEL THECKOUT LANGUAGE CHECKOUT EXEC PROGRAM ACCEPTANCE TESTING OF PROPULTION USE OF FLT COMP C/O EXITC PROGRATI C/O N'CEC REQUIREMENTS CHECKOUT REQUIREMENTS SEECE THIERPACH SPECS THE HARDWARE CHARACTURISTICS PROGRAM CHE OFEFATING DEVELOPMENT AND OPHEATIONS TACK FLOW CHECKOUT COFTWARE FLIGHT COMPUTER PROGRAM-DETAILED DEFIGURATION OF PRODUCTION USE OF GSR ACCEPTANCE TENTING OF MING CHAPACPERISTICS PROGRAM REQUIREMENTS GENERATE GSE ENEC GSE EXEC PROGRAM PRODUCE ASE EXIN EXEC PROGRAM PROGRAM DETAILED DEFINITION OF ASSEMBLER REQUIREMENTS ACCEPTANCE TESTING OF COMPILER/ASSEMBLER COMPILER/ASSEMBLER GENERATE COMPLER/ PRODUCTION USE OF SER INCLUDING SEE PRODUCE COMPILERY ASSEMBLER COMUDATER. **MECHANIZA** TION PHASE PRODUCTION DESIGN PHASE

# FLIGHT SOFTWARE DEVELOPMENT AND OPERATIONS TASK FLOW



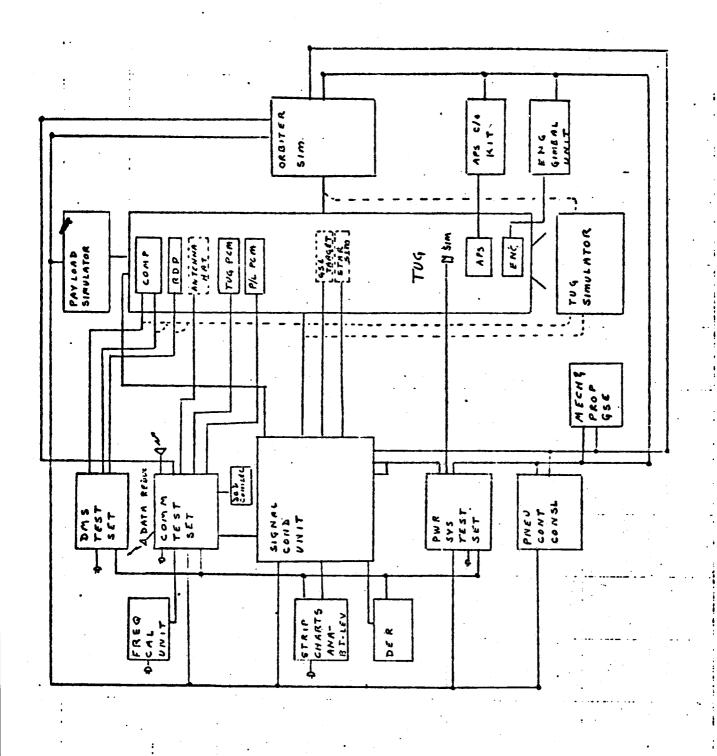
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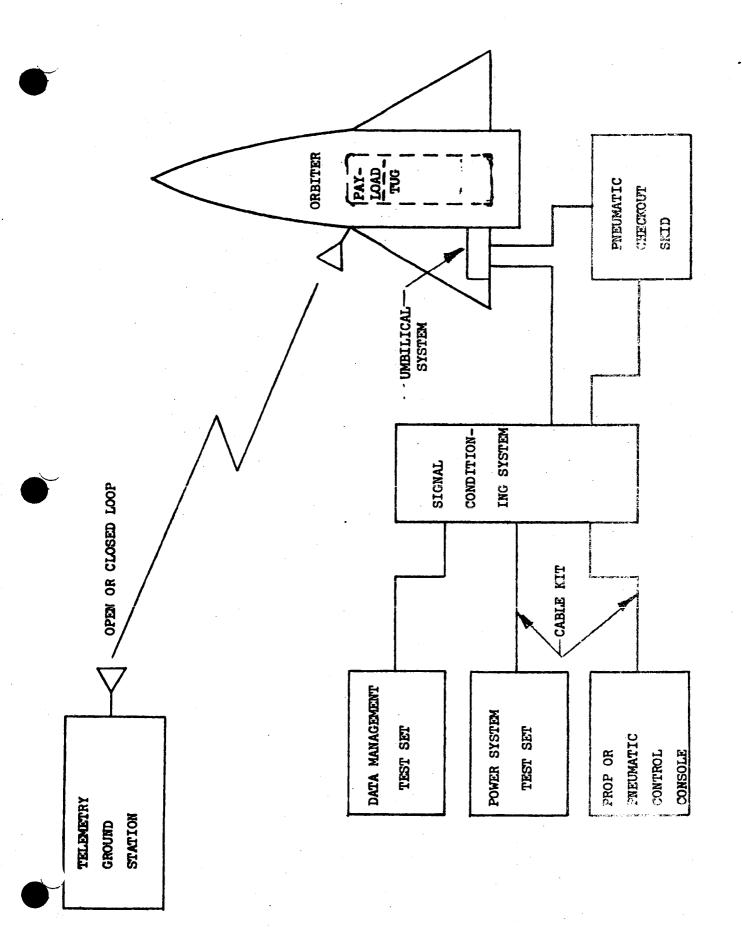


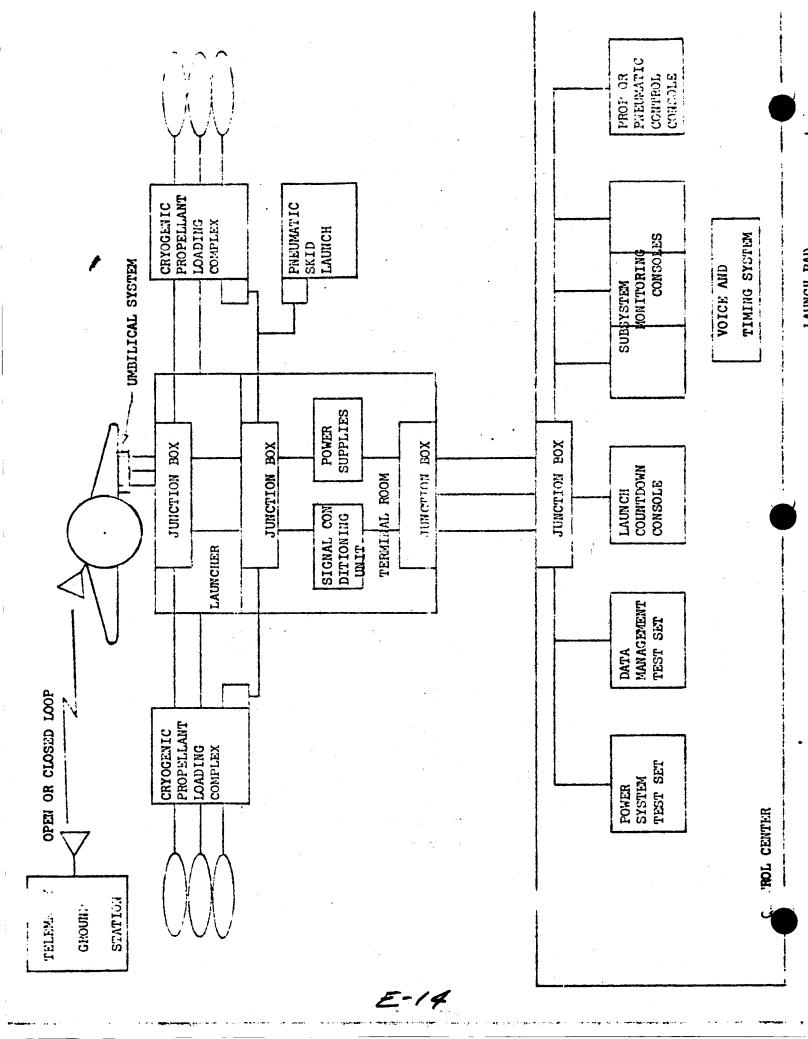
LAE AREA

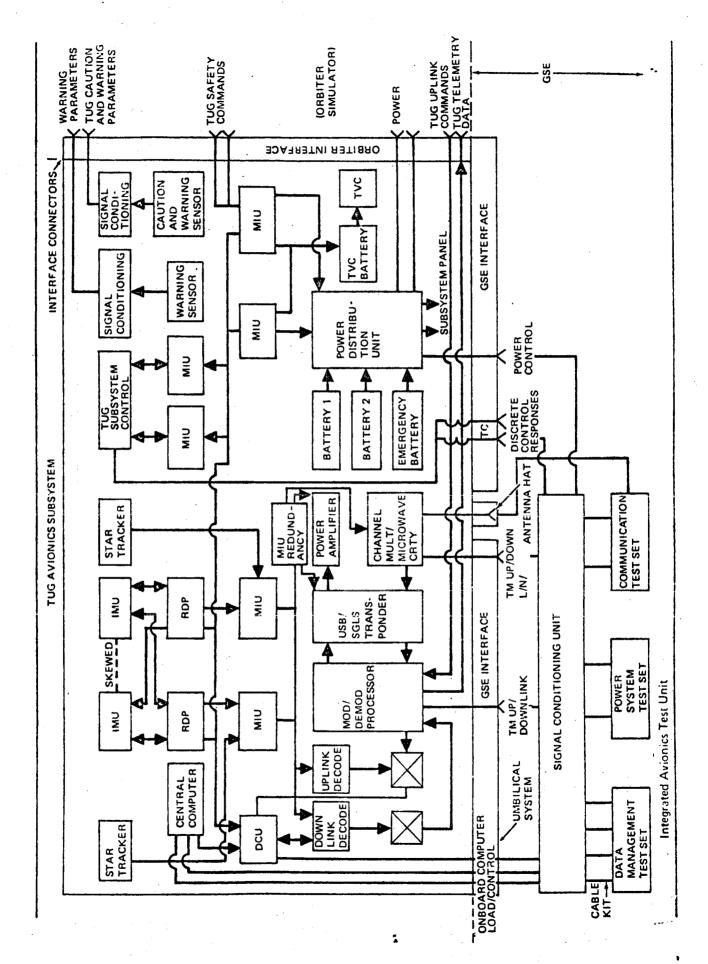
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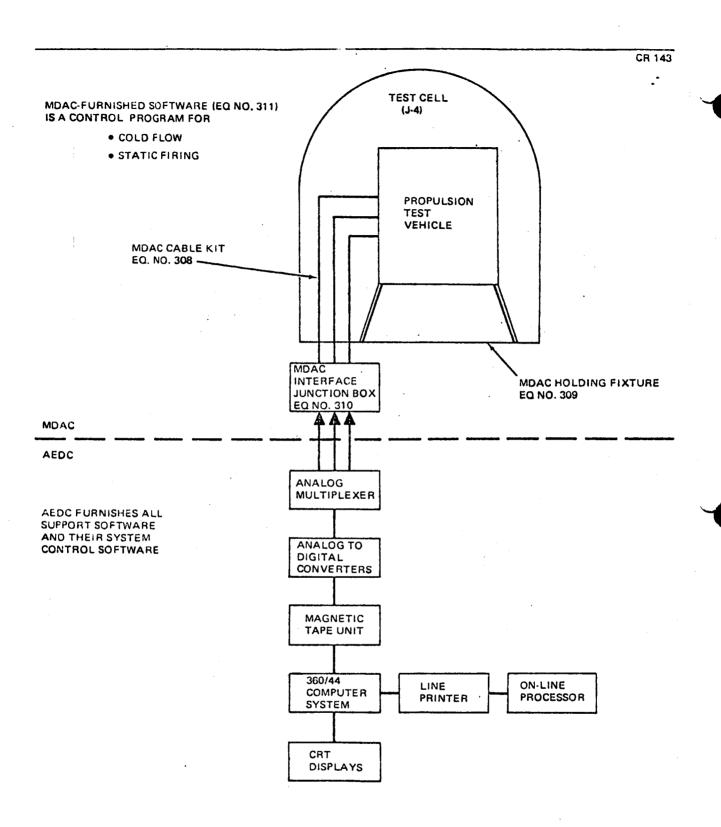




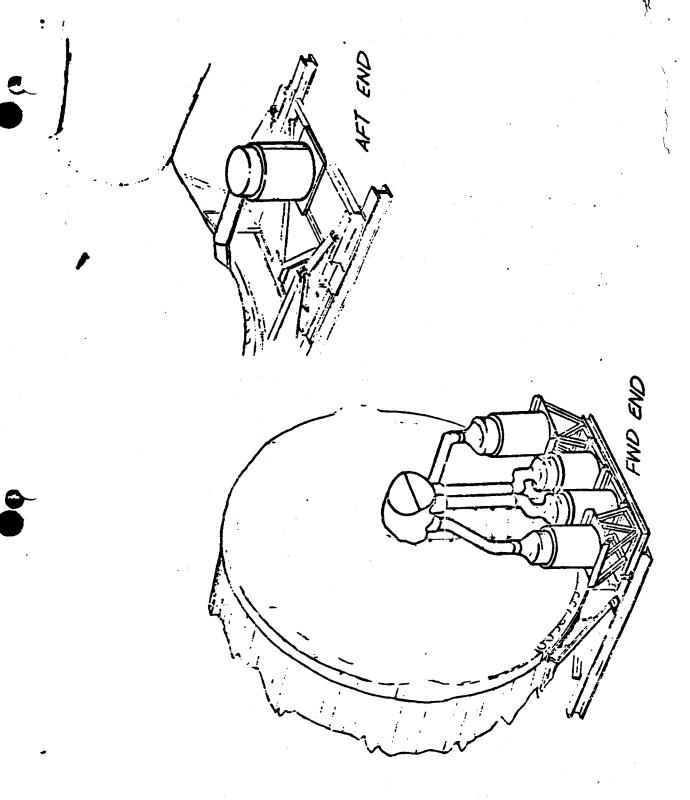








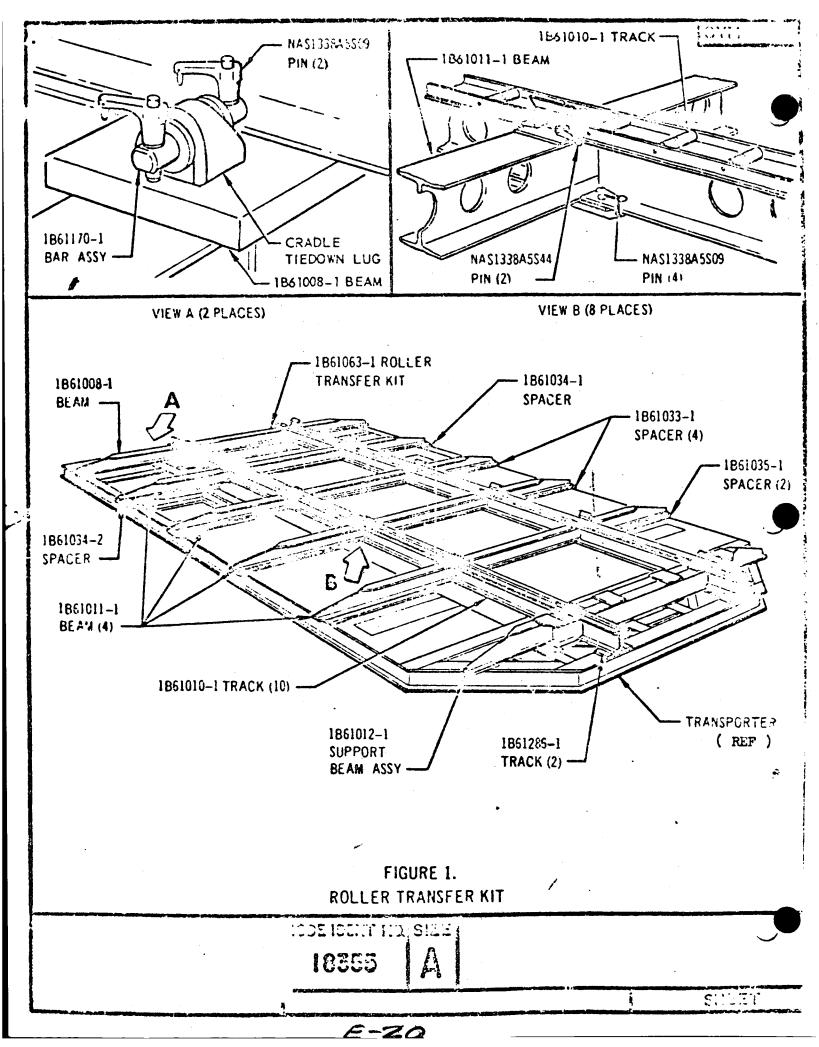
. Propulsion Test Vehicle/Ground Support Equipment Assembly



10 7

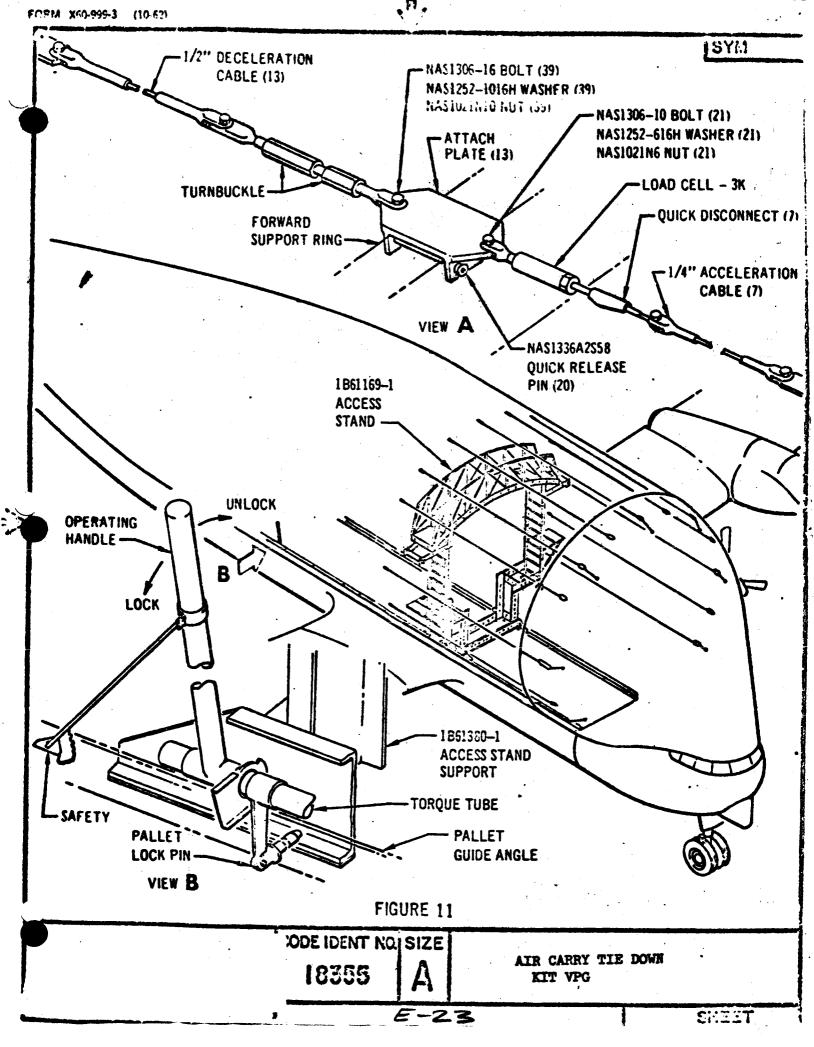
NAME: AIR CARRY ENVIRONMEN	TAL KIT VPG	EQUIPMENT NO. 104	
FUNCTIONAL REQUIREMENT(S)	:		
Maintains the stage fuel a	nd LOX tanks and the pro	pulsion subsystems in a cles	an
dry condition during trans	portation in the Super (	Auppy.	
EQUIPMENT DESCRIPTION:			
Similar to DSV-4B-1862			
cost \$	1200 (DESIGN A	AND DEVELOPMENT)	
\$	2400 (RECURRI		
EQUIPMENT CATEGORY:			
NEW	MODIFIED 10%	AS IS 90%	
	NUMBER AVAILABLE		
EQUIPMENT UTILIZATION:	•		
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
1.1.4	KSC	1	
		•	
	The transport of the second second section second section second section second section second section section second section section second section second section se		
**************************************			
			٠
****			
TOTAL REQUIRED	1 · TOTAL	cosr \$ 3600	

NAME: AIR CARRY ENVIRO	NMENTAL KIT VPG	EQUIPMENT NO. 105
FUNCTIONAL REQUIREMENT(	ត):	
Maintains the stage fue	l and LOX tanks and the	propulsion subsystems in a clean
dry condition during tre		
	•	
EQUIPMENT DESCRIPTION:		
Utilize DSV-4B-1862	(GPE)	
	\ <del></del>	
COST \$	0 (DESI	GN AND DEVELOPMENT)
	0 (RECU	
EQUIPMENT CATEGORY:		
MEW	MODIFIED	AS IS 100%
1ST YEAR REQ'D	NUMBER AVAILA	
EQUIPMENT UTILIZATION:		•
Functional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
1.1.4	KSC	1
		•
<del></del>		
	<del></del>	<del>(21)   1   1   1   1   1   1   1   1   1  </del>
TOTAL REQUIRED	1	TAL COST \$O_

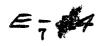


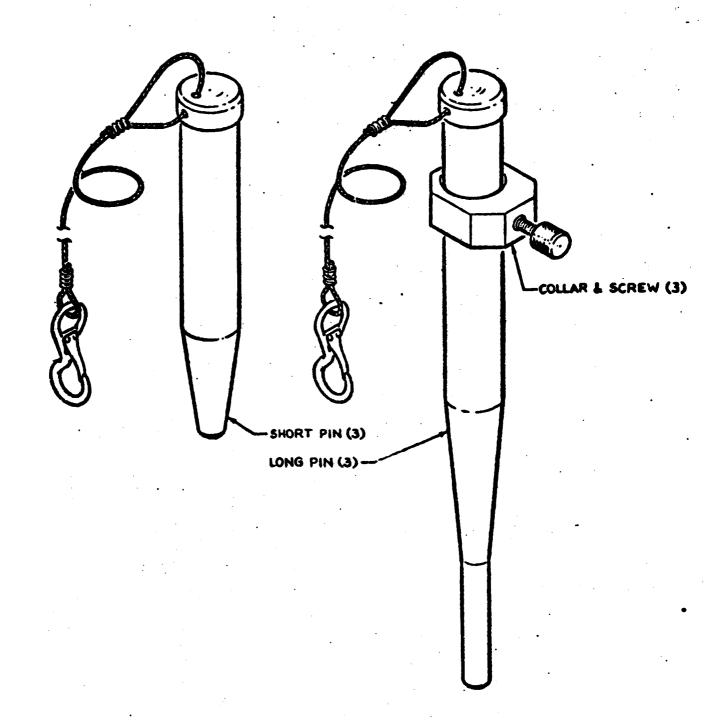
NAME: AIR CARRY RO	LLER TRANSP	ER KIT V	PG EQUIPMENT NO. 106
FUNCTIONAL REQUIRE	ement(s):		
Provides the means	of adaptir	ng the trans	porter to facilitate the transfering
of the stage when		-	
<i></i>			
EQUIPMENT DESCRIPT	'ION:		
Utilize DSV-4B-1	1863 (GFE)		
COST		^	
0001		_	(DESIGN AND DEVELOPMENT)
		-0-	(RECURRING/UNIT)
EQUIPMENT CATEGORY			
NEW_X		DIFIED	AS IS X
1ST YEAR REQ'D	<del></del>	NUMBER A	VAILABLE
EQUIPMENT UTILIZATI			•
Functional Flow block Number	·	LOCATION REQUIRED	
1.1.4	·	KSC	1
		WTR	1
	•		
	-		
	<del></del>		
	-	<del></del>	
TOTAL REQUIRED	2.		TOTAL COST \$ -0-

NAME: AIR CARRY	SUPPORT	VPG		_ EQUII	MENT NO. 107	·
FUNCTIONAL REQUIR	REMENT (S	3):				
Provides support	_		transnort	etion mo	den	
		se during arr	or anapor of	rozoti mo	463.	<del> </del>
4	<del></del>			· · · · · · · · · · · · · · · · · · ·		
	<del></del>	·	<del></del>	<del></del>		
EQUIPMENT DESCRIE	TION:					
Similar to DSV-4B-	-1859	·				
						<del> </del>
			<u> </u>			
COST	\$	20,000	(DESIGN	I AND DE	VET OPMENT!	
	·t	15,000				
·	₽	15,000	(RECURI	RING/UNI	T)	
EQUIPMENT CATEGOR						
NEW	-	MODIFIED_	50%	AS I	rs50%	
1ST YEAR REQ'D		NUMB	er availabi	LE	·	
EQUIPMENT UTILIZA	TION:			•		
FUNCTIONA FLOW BLOC NUMBER		LOCA REQU			NUMBER REQUIRED	
1.1.4		. KS	C		1	
		WI	R		.1	
**************************************	<del></del>		<del></del>	<del></del>		
		***************************************		-		
<del></del>	<del></del>	<del></del>	<del></del> .			
<del></del>	<del></del>		<del></del>			
		***************************************				
TOTAL REQUIRED		2	TOTAL (	OST	\$ 50,000	



NAME: AIR CARRY TIE DOWN	KIT - VPG	E	QUIPMENT NO. 10	8
FUNCTIONAL REQUIREMENT(S	s):			
Secures stage inside Supe		otects it fro	om undue accele	ration and
deceleration inertia.		<del></del>	· · · · · · · · · · · · · · · · · · ·	
<i>-</i>				
EQUIPMENT DESCRIPTION:				
Similar to DSV-4B-1861				
	·			
COST \$	4000	(DESIGN ANI	DEVELOPMENT)	~
<u> </u>	2500	(RECURRING,		
EQUIPMENT CATEGORY:				
	MODIFIED	į	AS IS	
1ST YEAR REQ'D		AVAILABLE		
EQUIPMENT UTILIZATION:			•	·
Functional	LOCATIO	האד	NUMBER	
Flow block Number	REQUIR		REQUIRED	·
1.1.4	KSC		1	
		· · · · · · · · · · · · · · · · · · ·	•	<del></del>
	•			
				<del></del>
		•		-
TOTAL REQUIRED	1.	TOTAL CO	ST \$ 6500	<del></del>

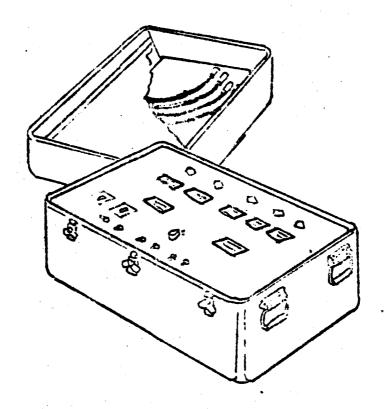




Alignment Kit,

E-25

NAME: ALIGNMENT	KIT			EQUIPMENT NO. 110
FUNCTIONAL REQUIS	reiænt (s	s):		
Provides necessar	y hardw	are for align	ment, install	lation, and staging to the
spacecraft.			<del></del>	-
EQUIPMENT DESCRIE	TION:			
Similar to DSV-4B	-340			
				•
***************************************		*		
COST	\$	7200	(DESIGN A	AND DEVELOPMENT)
•	\$	3300	(RECURRII	NG/UNIT)
EQUIPMENT CATEGOR	RY:			•
NEW_X		MODIFIED_		AS IS
1ST YEAR REQ'D		NUMB:	ER AVAILABLE	
EQUIPMENT UTILIZA	ATION:			•
Function/ Flow bloo Number		LOCA'		NUMBER REQUIRED
-		TP	F/KSC	<u>i</u>
		PP	F/KSC	11
		PP	F/WTR	1
			·	
<del>*************************************</del>				
<del>and Sillman and a same</del> n		***************************************		
TOTAL REQUIRED	<del></del>	3	TOTAL	COST \$ 17,100



APS BREAKOUT CONTROL BOX

Configuration	OPTION	

		EQUIPMENT NO. 111
runctional requirement(s)	):	•
Provides individual ele	ctrical control of the	APS thruster valves and isolation
valves for checkout.		
£		
QUIPMENT DESCRIPTION:		•
Twelve cable assemblies,	suitcase assembly which	ch contains one momentary sw., five
		indicator lamps, two circuit break
		nectors, and associated wiring.
(Similar to DSV-7-106).		
. \$	500 (DESIG	I AND DEVELOPMENT)
<u>.</u>	``	RING/UNIT)
QUIPMENT CATEGORY:	(1000)	
NEW X	MODIFIED 50%	AS IS 50%
,	NUMBER AVAILABL	
QUIPMENT UTILIZATION:	NOW MAKE AVAILABLE	
FUNCTIONAL	LOCATION	
FLOW BLOCK NUMBER	REQUIRED	NUMBER REQUIRED
New Checkout and 1.1.11	TPF/KSC	1
New Checkout and 1.1.11	PPF/WTR	7
	Factory	1
		·····

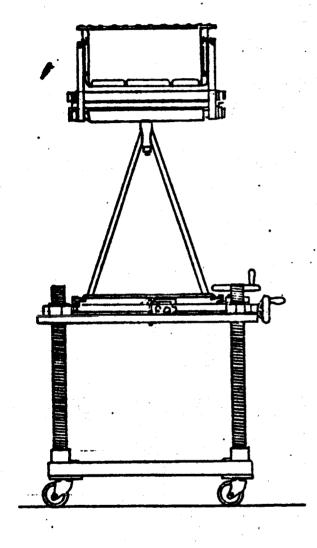
CONFIGURATION OPTION	
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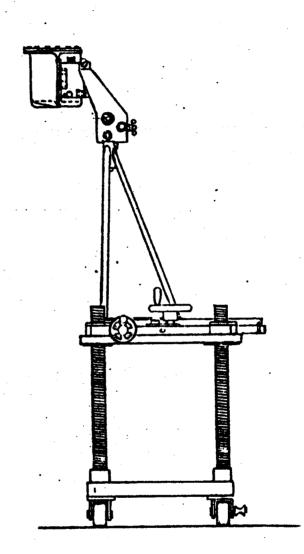
MAME: APS LOADING ACCES	SORIES KIT	EQUIPMENT NO. 112	
PUNCTIONAL REQUIREMENT (	s):		
To adapt APS servicer	to vehicle and provide	miscellaneous tools	and equipment
required for storable			<del>4</del>
14datted for proteste	ALO TOMATIO.		
			·
<u> </u>			
EQUIPMENT DESCRIPTION:			
Collection of hoses,	tools, and other equipme	ent for use in APS lo	ading and
unloading operations.			
			<del></del>
			·
CONT \$	1000 (DESI	GH AND DEVELOPMENT)	
•	2000 (RECU	RRING/UNIT)	
The control of the co			
EQUIPMENT CATEGORY:	,		
NEA X	MODIFIED	AS IS	
1ST YEAR REQ'D	MUMBER AVAILAB	LE	-
EQUIPMENT UTILIZATION:			1.
Functional Flow block Number	LOCATION REQUIRED	Number Required	
2.1.7	Storable/KSC	1	_
	Storable/WTR	1	_
			-
	Factory		•
<del>*************************************</del>			•
			-
· · · · · · · · · · · · · · · · · · ·			·
		•	
TOTAL REQUIRED	3	AL COST \$ 7.000	

CONFIGURATION	OPTION
CONFIGURATION	OPTION

ystems.
····

SYM





CODE IDENT NO. SIZE

BATTERY HANDLING KIT

HEET

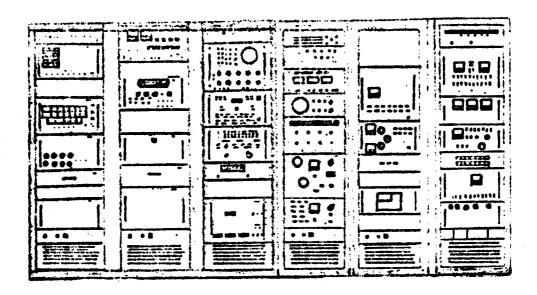
CONFIGURATION	OPTION	
---------------	--------	--

NAME: BATTERY HANDLING KIT			FOULPMENT NO. 115		
FUNCTIONAL REQUI	rement(s):			. •	
Provides installa	tion of bat	teries in st	tage when in	horizontal or vertical	
position.					
		:			
<i>*</i>					
EQUIPMENT DESCRI	PTION:				
Similar to DSV-4E	3-400				
				the the second	
Cost	\$	10,000	(DESIGN A	ND DEVELOPMENT)	٠.
	\	2,000	_ (RECURRING		
EQUIPMENT CATEGO	<u> </u>		_ (IDCOIDEAN		
NEW NEW		ODIFIED	5 <b>%</b>	AS IS 95%	
1ST YEAR REQ'D	<del></del>				
EQUIPMENT UTILIZ			,	•	
FUNCTION FLOW BLO	IAL	LOCATION REQUIRE		NUMBER REQUIRED	
NUMBER	0	TPF/		1	,
1.1.6		<del></del>			
		PPF/	MIK	1	
<del></del>	·				
<del></del>		<del></del>	<del></del>		
			. <del></del>		
<del></del>				A Company of the Comp	

CONFIGURATION O	PTION
-----------------	-------

NAME: CHECKOUT ACCESSOR	IES KIT	EQUIPMENT NO. 117
runctional requirement(s	):	
Assembles miscellaneous		for test and checkout.
<u> </u>		
EQUIPMENT DESCRIPTION: Collection of hoses, ga	ge-regulator assemb	lies, fittings, leak test equipment,
test plates, flow meter	s, and other miscel	laneous checkout equipment.
COST \$	(2)	ESIGN AND DEVELOPMENT)
<b>\$</b>	3000 (R	ECURRING/UNIT)
EQUIPMENT CATEGORY:		
•	MODIFIED X	AS IS
		ILABLE
EQUIPMENT UTILIZATION:	· · · · · · · · · · · · · · · · · · ·	
Functional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
1.1.7.1	KSC	
	<u> </u>	<u> </u>
TOTAL REQUIRED	8	TOTAL COST \$ 24,000

NAME: CHECKOUT CABLE KIT	·	FOULPHFUT NO. 118
functional requirement(s):		
Provides interconnects be	etween test sets, ve	ehicle, power, etc.
	•	
EQUIPMENT DESCRIPTION:		
Consists of all cable,	(power, RF, signal)	required to support Tug
Unique checkout in all	areas. Cable netwo	rk - 70 cable assemblies
(80 ft) long - (35 60 p	in cables; (18) 4 p	in cables; (5) 39 pin
cables; 7 coax cables;	(5) 24 pin cables;	breakout cables and general
EQUIPMENT CATEGORY:	odified 30%	RING/UNIT) AS IS
1ST YEAR REQ'D	NUMBER AVAILABI	LE
EQUIPMENT UTILIZATION:		
Functional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
1.1.5,1.1.7 ALL	KSC	5 5
1.1.8 ALL	WTR	4
1.1.9 ALL	Factory	1
1.1.14		
2.3.9. 2.4.2		
		41. cocr \$ 64,500
TOTAL REQUIRED 10	TOT	AL COST \$ 04,500



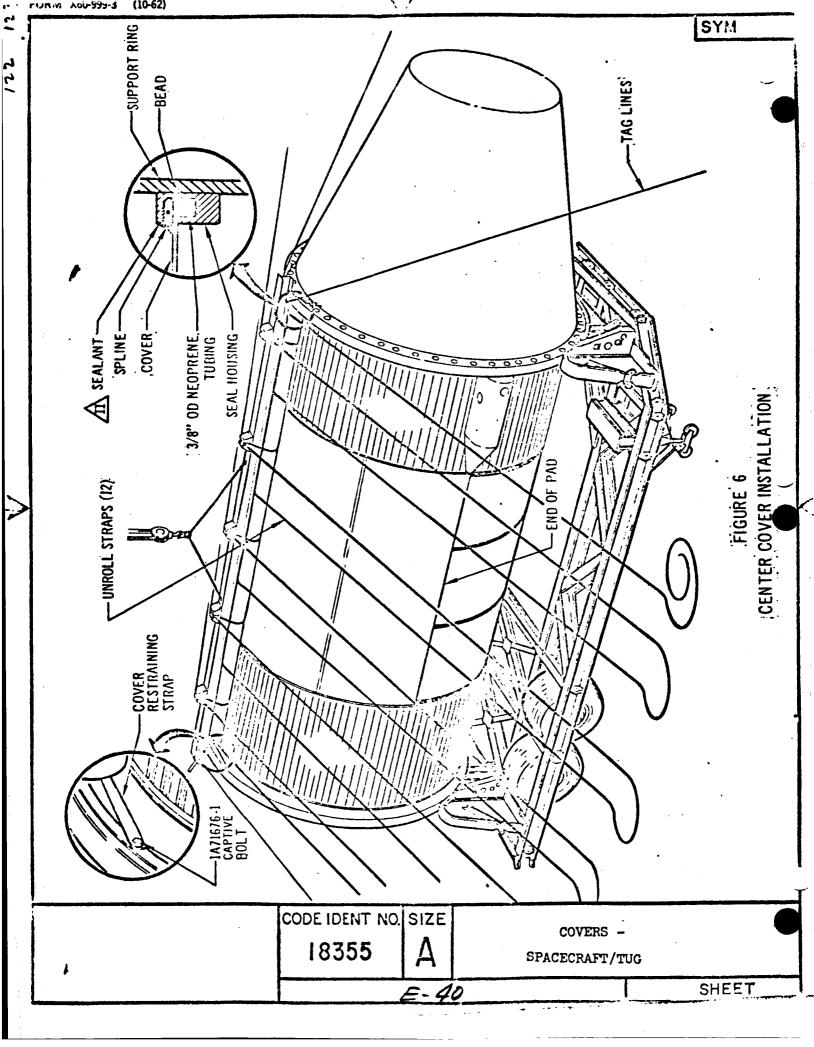
COMMUNICATION SYSTEM TEST SET

NAME: COMMONICATION	SISTEM TEST SET	FOULIMI	NT NO. 119
FUNCTIONAL REQUIREMENT	'(s):		
Receives, demodulates P	CM data from space	craft, provides	for output to computer
storage, contains displ			
routing of data to exte			•
locally or through comp			
EQUIPMENT DESCRIPTION:			
See attachment.		•	
			ė
COST PER UNIT: \$	634,000	(NON-RECURRING)	
\$	533,000	(RECURRING/YEAR)	
EQUIPMENT CATEGORY:		(IIII)	
NEW X	MODIFIED	97 PA	
1ST YEAR REQ'D	<del>4.450 4.540</del>		
EQUIPMENT UTILIZATION:		·	<del></del>
TUNCTIONAL	•		
FLOW BLOCK NUMBER	LOCATION REQUIRED		NUMBER EQUIRED
1.1.8.9	TPF/KSC		1
1.1.9.9	PPF/WTR		1.
	Factory		1
	-	:	
	-		
TOTAL REQUIRED	3	TOTAL COST \$_	2.766.000
		· •	

EQUIPMENT DESCRIPT	QTY	FACTORY	LAUNCH DE-ORBIT	REMARKS
X-Y Recorder	1	X	*	*Equipment to be
Sweep Oscillator	1	<b>X</b>	*	made available
Signal Generator	1	X	•	at launch complex
VSWR Meter	Ĺ	X	*	in the event of
RF Power Meter	1	X	•	transmission
Misc. Equipment	TBD	X	*	failures.
Frequency Counter	1	x	x	Similar to DSV-
Frequency Converter	1			4B-123 and DSV-
S-Band Test Transmitter	2			4B-125
S-Band Test Receiver	. 2		•	
S-Band FM Receiver	1			
Payload PCM Demodulator	1			
SGLS/NASA PCM Demodulator	1			
PCM Decommutator	2			
PRN Ranging Assembly (SGLS/NASA)	2			
Error Rate Measuring Unit	1			
Command Signal Conditioner (SGLS/NASA)	2			
Regulated Power Supply	2			
Logic Power Supply	2			
PCM Simulator	1			
Oscilloscope	1			
Calibration Test Panel	1			
Manual Control Panel	1	•		
RF Switch Panel	1			
Source Selector Panel	1			
RF Attenuator Panel	1			
Quick Loop Panel	2			
Voice Communication Panel	3			
RMS Voltmeter	1			
Circuit Breaker Panel	2			•
Patch Panel	1			
Analog Strip Chart	3			Similar to DSV-
Bilevel Strip Chart	3			4B-240, DSV-4B-
FM Oscillograph	2			238, DSV-4B-239
Digital to Analog Converters	80	•		
Gaivanometer Drive Amplifiers E-37	6			

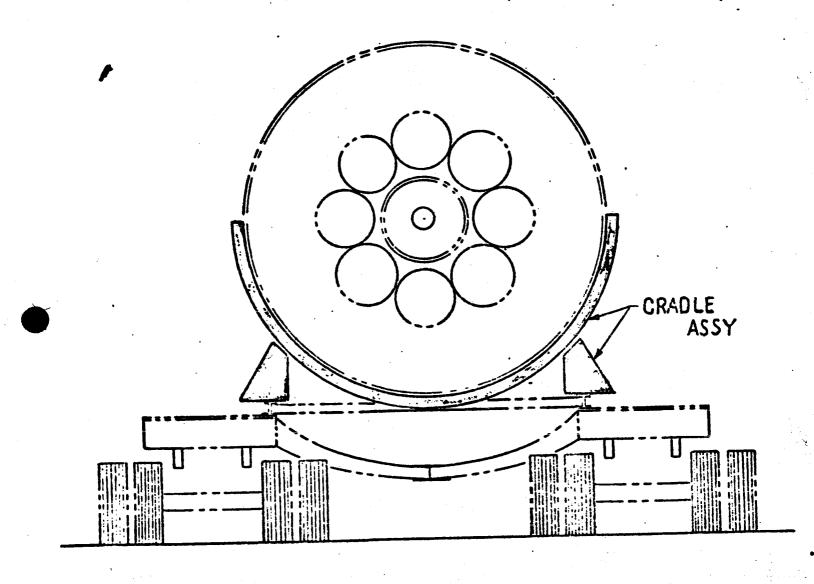
NAME: COMPONENT F	ROTECI	IVE COVERS		EQUIPMENT NO. 120	
FUNCTIONAL REQUIRES	ænt(s)	):	est.		
Provide prelaunch	protec	tion for vulner	able compo	onents. Removed prior	to launch
and returned to fa	ctory	for re-use.			
	<del></del>				
		·			
<u> </u>					****************
EQUIPMENT DESCRIPT			•		
				and other components	subject
to ground handling	dama <sub>(</sub>	ge, including G	C lens con	rers.	
-					
Cost	\$	2000	(DESIGN	AND DEVELOPMENT)	
	· \$	700	(RECURRI	MG/UNIT)	
EQUIPMENT CATEGORY	•		•	,	
NEWX		MODIFIED		AS IS	
1ST YEAR REQ'D_		NUMBER	AVAILABLE		
EQUIPMENT UTILIZAT	ION:			• .	
Functional Flow block number		LOCATIO REQUIRE		NUMBER REQUIRED	
1.1.4		· KSC		3	
1.1.20		WTR		٤	
		<del></del>			
		<del></del>			
TOTAL REQUIRED	<del></del>	5	TOTAL	COST \$ 5,500	

e telemetry
lemetry ground
<del></del>
r)
:
<u>E)</u>
l CD
<del></del>



NAME: COVER -	SPACECRAFT	EQUIPMENT NO. /122
FUNCTIONAL REQUIRE	enert(s):	
To provide e	environmental and	physical protection to a SC while
it is joined	i to the Tug on the	e transporter.
EQUIPMENT DESCRIPT	rion:	
		over for the SC designed to integrate
	•	
with the Tug	cover as a replac	cement for its forward section.
COST FER UNIT:	\$ 3.000	(DESIGN AND DEVELOPMENT)
	\$500	(RECURRING/UNIT)
EQUIPMENT CATEGORY	•	
NEW X	MODIFIED	AS IS
1ST YEAR REQ'D	•	BER AVAIIABLE 0
		DER AVAITABLE
EQUIPMENT UTILIZAT FUNCTIONAL		
FLOW BLOCK NUMBER	LOCA	ATION NUMBER UIRED REQUIRED
1.1.4	KSC	<b>4</b>
1.1.2.1	WTR	1
1.1.2.6		
<del></del>		
2.3.6		
2.4.8		
<del></del>		
	5	5,500

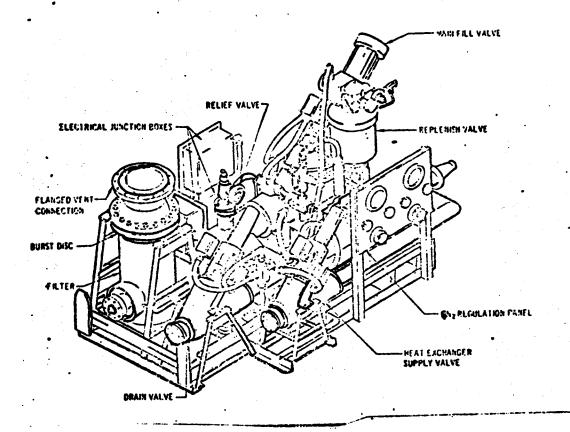
AKE: Cover-Tug			QUIPMENT NO	123
UNCTIONAL REQUIRE			+ +b M	
<del></del>		nd physical protection	<del></del>	<del></del>
during transpo	ort protection	n to the Tug during t	transport and	
storage in the	e horizontal	position.		
QUIPMENT DESCRIP	TION:			
A rubber impreg	nated nylon f	abric cover fabricate	ed to V shape in	three
		on the Tug by laced		
Bekmenes wiren				<del></del>
	- <u></u>			<del></del>
				<del></del>
COST FER UNIT:	\$3500	(DESIGN A)	ND DEVELOPMENT)	
	\$ 800	(RECURRING	G/UNIT)	
EQUIPMENT CATEGOR	٧.			
X	r	ra Tra	40 TO	
NEW	MOD1		AS IS	
1ST YEAR REQ'D_		_ NUMBER AVAILABLE _	0	
- RQUIPMENT UTILIZA	TION:		•	
FUNCTIONA FLOW BLOC	iL.	LOCATION REQUIRED	number Riquired	
FUNCTIONA FLOW BLOC NUMBER	iL.		numer	
FUNCTIONA FLOW BLOC	iL.	REQUIRED	HUMBER RIQUIRED	-
FUNCTIONA FLOW BLOC NUMBER 1.1.2.1 1.1.22	iL.	REQUIRED  KSC	HUMBER REQUIRED	
FUNCTIONA FLOW BLOC NUMBER 1.1.2.1	iL.	REQUIRED  KSC	HUMBER REQUIRED	
FUNCTIONA FLOW BLOC NUMBER 1.1.2.1 1.1.22	iL.	REQUIRED  KSC	HUMBER REQUIRED	
FUNCTIONA FLOW BLOC NUMBER 1.1.2.1 1.1.22	iL.	REQUIRED  KSC	HUMBER REQUIRED	
FLOW BLOC NUMBER 1.1.2.1 1.1.22	iL.	REQUIRED  KSC	HUMBER REQUIRED	



**CRADLE ASSY** 

NAME: CRADLES		EQUIPMENT NO. 124
FUNCTIONAL REQUIREME	IT(S):	
To provide a means	to support and restrain	the Tug on its transporter.
P EQUIPMENT DESCRIPTION		
An intermediate st	eel structure to fit bet	ween and attach to the Tug
and transporter.		
`		
COST PER UNIT:	\$ 100,000 (DES	IGN AND DEVELOPMENT)
	\$ 65,000 (REC	URRING/UNIT)
EQUIPMENT CATEGORY:	Y <del>ou</del>	
NEW X	MODIFIED	AS IS
	NUMBER AVAII	0
EQUIPMENT UTILIZATIO		
PUNCTIONAL	LOCATION	number
FLOW BLOCK NUMBER	REQUIRED	REQUIRED
1.1.20	KSC	4 -
	WTR	1
	Factory	1
TOTAL REQUIRED	5 '1	rotal cost \$ 425,000

E-44



CRYOGENIC PROPELLANT LOADING COMPLEX

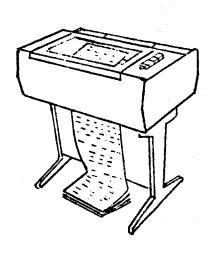
E-45

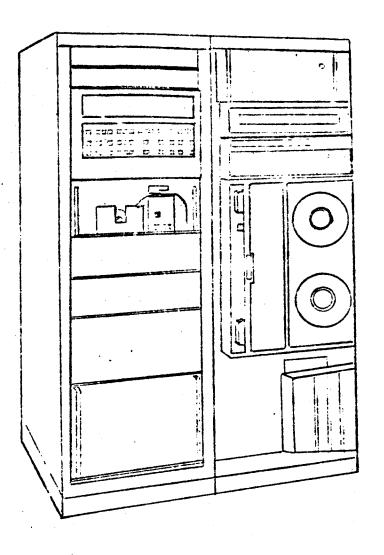
CUNFIGURATION	OPTION	•

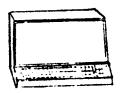
NAME: CRYO. PROPELL	ANT LOADING COMPLEX	EQUIPMENT NO. 125
FUNCTIONAL REQUIREM	ent(s):	
Provide for transf	er and control of LO2 and Li	from facility to vehicle
umbilical.		
f .		
EQUIPMENT DESCRIPTION	on:	
LH2 and IO2 loading	g complex utilizing hardward	e from Sacramento Test Center
		ilicals, etc.) (Utilize Shuttle
topping system.)	Same as DSV-4B-331 and -332	2.
0000	\$ 40,000 (DESI	GN AND DEVELOPMENT)
Cost	-	
·	\$ 20,000 (RECU	RRING/UNIT)
EQUIPMENT CATEGORY:	<b>Y</b>	AS IS X GFE facilities at ETR
NEW	MODIFIED X	
1ST YEAR REQ'D_	NUMBER AVAILAB	LE
EQUIPMENT UTILIZATI	ON:	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	number Required
2.4.3	KSC	2
	WTR	1
***************************************		
***************************************		
TOTAL REQUIRED	3 TOT	TAL COST \$ 100.000

CONFIGURATIO	N OPTION
--------------	----------

-	EQUIPMENT NO. 126	
٥١.		
8):		
yogenic propellants during	post launch safing	
		· · · · · · · · · · · · · · · · · · ·
s. GFE at facility.		
		· · · · · · · · · · · · · · · · · · ·
· · · · · · · · · · · · · · · · · · ·		<del></del>
(DESIGN A	AND DEVELOPMENT)	
(RECURRIS	NG/UMIT)	
	•	
MODIFIED	AS IS X	
NUMBER AVAILABLE		
	•	
7.084 <b>8</b> 704	to the colors	
REQUIRED	REQUIRED	
LPPR	1	
**************************************		
	s. GFE at facility.  (DESIGN (RECURRITY)  MODIFIED	s. GFE at facility.  (DESIGN AND DEVELOPMENT)  (RECURRING/UNIT)  MODIFIED AS ISX  NUMBER AVAILABLE  LOCATION NUMBER REQUIRED  REQUIRED REQUIRED







DATH MANAGEMENT TEST SET

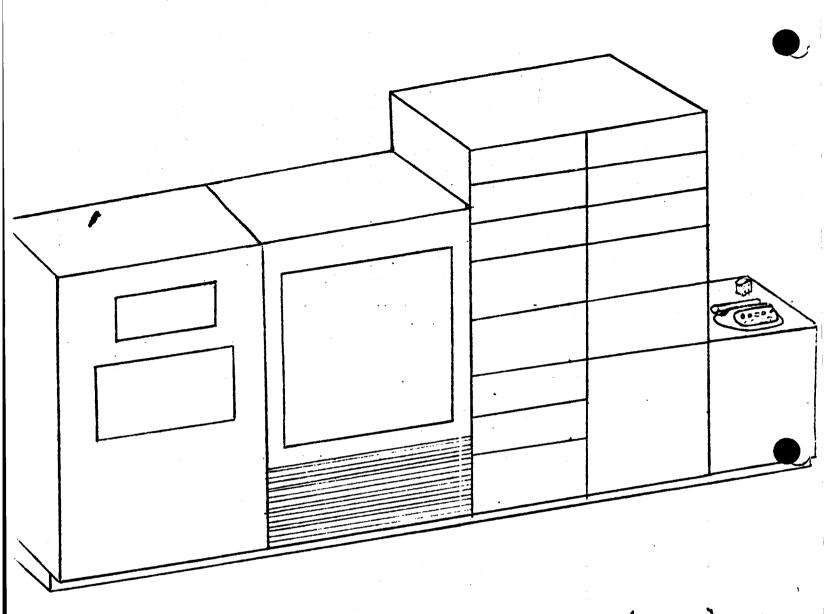
CONF	TGIR	ATION	OPTION
COME	TAOTI	WI TON	OPTION

WEIG.	SYSTEM T/S (DMST/S)	EQUIPMENT NO.	. 2 (
FUNCTIONAL REQUIREMENT(	s):		
Controls operation of D		es computer status, in	tials program
loading and verification			
control functions, inte	rface with other T/S fo	or dedicated displays,	verify
selected subsystem para	meters as program.		
EQUIPMENT DESCRIPTION:			
Portable console interf	acing with computer for	r program verification	and DMS memor
dump C/O, paper tape me			
panel, dedicated displa	y panel for DMS function	on and programmable di	splay for othe
subsystem functions (GN	C, Comm, Power, and Pro	op.) - CRT	
COST PER UNIT: \$	1,033,000 (NON-)	RECURRING)	
*		RRING/YEAR)	
Ψ	[ TE()()	U:V-1(O) 1 L.M. /	
EQUIPMENT CATEGORY:			
•	MODIFIED	AS IS	
NEW_X	MODIFIEDNUMBER AVAILA	AS IS	
NEW_X 1ST YEAR REQ'D		AS IS	
NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION: FUNCTIONAL		AS IS	
NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:	NUMBER AVAILA	AS IS	
NEW_X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	NUMBER AVAILATION REQUIRED	AS ISBLENUMBER	
NEW_X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.5, 1.1.7 AL	NUMBER AVAILAD  LOCATION  REQUIRED  L TPF/KSC	AS IS BLE NUMBER REQUIRED	
NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.5, 1.1.7 AL  1.1.8 ALL, 1.1.	LOCATION REQUIRED  TPF/KSC  ALL MCF/KSC	AS IS BLE  NUMBER REQUIRED  1	
NEW_X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.5, 1.1.7 AL	LOCATION REQUIRED  TPF/KSC  9 ALL MCF/KSC  Launch Pad/KSC	AS IS BLE  NUMBER REQUIRED  1 1 2	
NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.5, 1.1.7 AL  1.1.8 ALL, 1.1.	LOCATION REQUIRED  TPF/KSC  9 ALL MCF/KSC  Launch Pad/KSC  PPF/WTR	AS IS  NUMBER REQUIRED  1 2 1	
NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.5, 1.1.7 AL  1.1.8 ALL, 1.1.	LOCATION REQUIRED  TPF/KSC  9 ALL MCF/KSC  Launch Pad/KSC	AS IS BLE  NUMBER REQUIRED  1 1 2	

NAME: TELEMETRY G	ROUND STA	ATTON			FOO.	LITHLICT	по	120		
FUNCTIONAL REQUIRE	MENT(S):									
Receives and demod	ulates P	CM data f	rom Tu	g down	link	either	open	or	close	d loop.
Provides for output	to comp	uter stor	age or	conve	rsion	of dat	a to	exte	rnal	display
units.									·	
EQUIPMENT DESCRIPT										
See attachment.										
	<del></del>		<u></u>							
			P							
							<del></del>			<del></del>
COST PER UNIT:	\$	-0-		(non-re	CURRI	NG)				
	\$	-0-		(RECURE	ing/y	ear)				
EQUIPMENT CATEGOR	Y:									
NEW		MODIFIED	)		AS	IS	(			
1ST YEAR REQ'D		NU	MBER A	VAILABI	LE				_	
EQUIPMENT UTILIZA						•				
FUNCTIONA			NO A MITON			7.11	MBER			
FLOW BLOC NUMBER			CATION EQUIRED				UIRE	)		
			(remote				•			
2.3.9		WTR	ch pad (remote	e from					-	
2.4.3		laun	ich pad	)			1		-	
						<del></del>		<del></del>	-	
·									_	
									-	
		3		#POTO	AL CO	cutto 💠	-0	) <b></b>		
TOTAL REQUIRED		2		101	NT CO	·/				-

The Western Test Range has a 30 foot Unified S-Band (USB) remote tracking site which is part of the spaceflight Tracking and Data Network (STDN). The "unified" concept of the USB system provides multiple functions -- command, telemetry, tracking and two-way voice communications -- to be accomplished simultaneously between 2090 and 2120 MHz and a downlink frequency between 2200 and 2300 MHz.

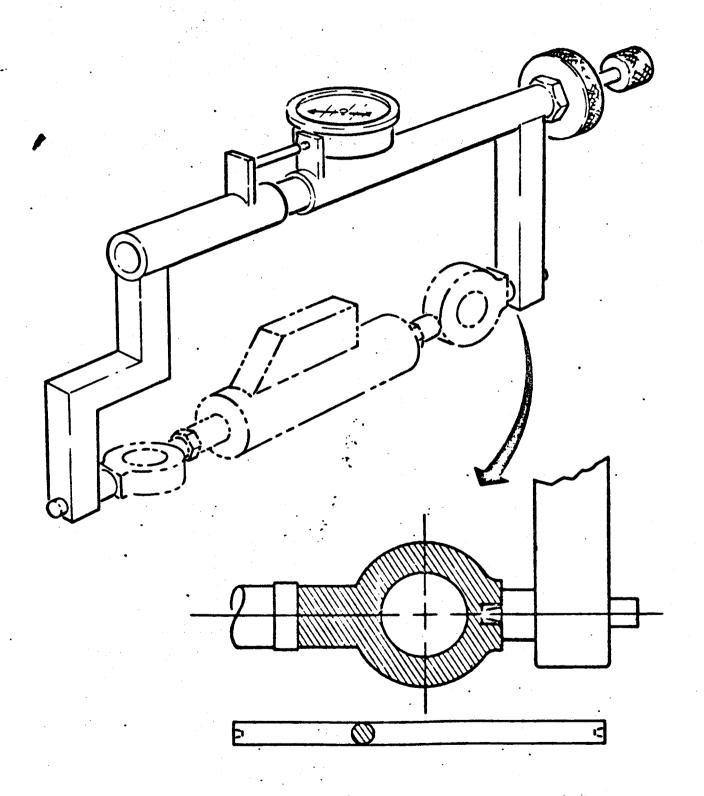
The Eastern Test Range has a dual AFSCF remote tracking station (RTS) located at Vandenberg California capable of operating with two satellites simultaneously. The RTS contains S-band equipment designated as a Space Ground Link Subsystem (SGLS) installation. The SGLS equipment is standardized and interfaces with two antennas, one is a 60 foot antenna while the other is a 46 foot dish. The SGLS contains receiving and transmitting equipment necessary for data reception and commanding of space vehicles.



DIGITAL EVENTS RECORDER (DER)

CONFIGURATION	OPTION
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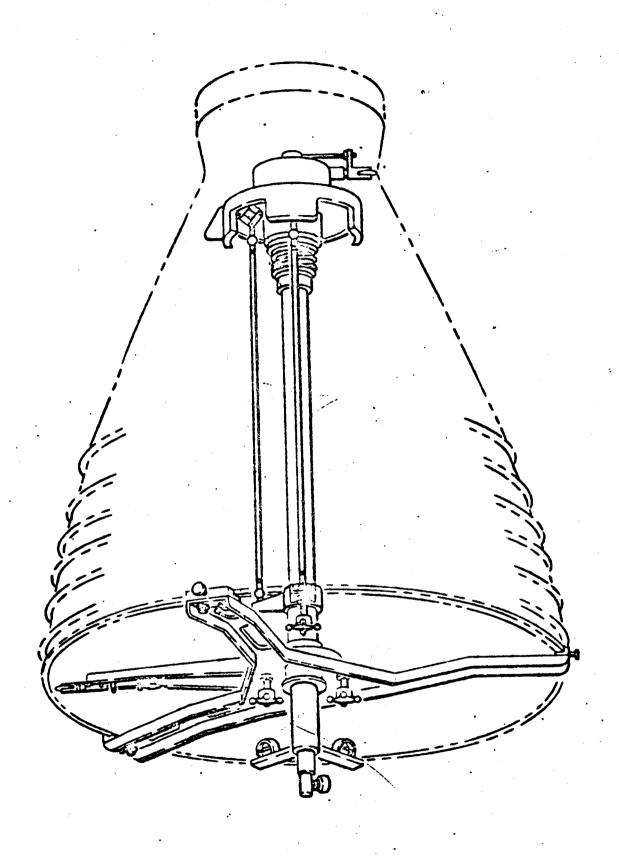
(s):					
us (on/off) date	and com	ares da	ta against	previous	ily
Prints or tape	punches o	output r	esults for	permaner	nt recor
		,			
	1.4.1				
			,		
					:
<del> </del>		<del>,</del>	p :	<del></del>	
200,000	(NON-R	ECURRING	<b>;)</b> ,		
182,000	(RECUR	RING/YE/	(A)		
				•	
MODIFIED		AS :	is		
	R AVAILAR				
•					
=		•		•	
<b>~~~</b> (	mae l		7 CI	PTP	
	: 4				
					A A
Facto	ry		<u>l G</u>	FE	
				<del></del>	
	<del>میشدند بین بین بین بین</del> بی	·		<del></del>	
		· <u></u>	N. Company	ed <u> </u>	
	Prints or tape  200,000  182,000  MODIFIED  NUMBE  LOCAT  REQUI	Prints or tape punches of tape	Prints or tape punches output results or tape punches output r	Prints or tape punches output results for  200,000 (NON-RECURRING)  182,000 (RECURRING/YEAR)  MODIFIED AS IS  NUMBER AVAILABLE  LOCATION REQUIRED  REQUIRED REQUIRED  ESC (TFF) 1 G  WTR (PPF) 1  Factory 1 G	Prints or tape punches output results for permaner  200,000 (NON-RECURRING)  182,000 (RECURRING/YEAR)  MODIFIED AS IS  NUMBER AVAILABLE  LOCATION NUMBER REQUIRED  REQUIRED REQUIRED  ESC (TFF) 1 GFE  WTR (PPF) 1  Factory 1 GFE



Engine Actuator Adjustment Kit

CONFIGURATION	ADMITAN
COUL TOOUNT TOU	OPTION

-		IXTURE		EQUIPMENT NO	
UNCTION	MI. REQUIREMENT (S	<b>5):</b>			
eckout	electrical/mecha	nical actuator	s on Tug.		
		9 			
				:	**.
<u> </u>			<del>,</del>		·
QUIPMEN	NT DESCRIPTION:	•			
	··		************************************		
cost pei	R UNIT: \$	10,000	(NON-REC	urring)	•
•	<b>\$</b>	4,000	(RECURRI	NG/YEAR)	
	em gimpsopy.				
equip/e	TT CATEGORY:				
N	EW			· AS IS	
n					
n 1st y	EAR REQ'D				
n 1st y	EW	NUMB:	ER AVAILABLI		•
n 1st y	EAR REQ'D		er availabli		
n 1st y	EAR REQ'D	LOCA'	ER AVAILABLI FION IRED	enumber	
n 1st y	EAR REQ'D	LOCA' REQU	ER AVAILABLE	NUMBER REQUIRED	
n 1st y	EAR REQ'D	LOCA' REQUI	ER AVAILABLE	NUMBER REQUIRED  1	
n 1st y	EAR REQ'D	LOCA' REQU	ER AVAILABLE	NUMBER REQUIRED	
n 1st y	EAR REQ'D	LOCA' REQUI	ER AVAILABLE	NUMBER REQUIRED  1	
n 1st y	EAR REQ'D	LOCA' REQUI	ER AVAILABLE	NUMBER REQUIRED  1	
n 1st y	EAR REQ'D	LOCA' REQUI	ER AVAILABLE	NUMBER REQUIRED  1	



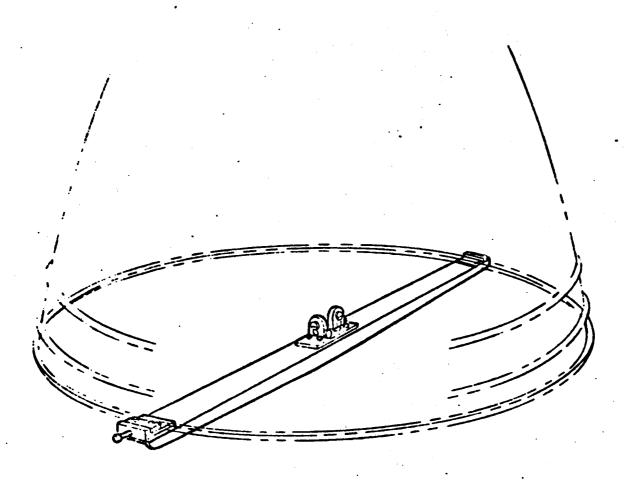
Engine Alignment Kit

CONFIGURATION	OPTION	

•	KIT	QUIPMENT NO. 131	
FUNCTIONAL REQUIREMENT(S	3):		
stablishes centerline of	f engine with respect to st	age centerline.	
			<del> </del>
QUIPMENT DESCRIPTION:			
imilar to DSV-4B-324			
			<del></del>
·			· · · · · · · · · · · · · · · · · · ·
**************************************	<del></del>	······································	
	<del></del>		·
ost \$	25.000 (DESIGN AN	D DEVELOPMENT)	
•			
	15,000 (RECURRING	/UNIT)	
EQUIPMENT CATEGORY:	•		
NEM X	MODIFIED 15%	AS IS 85%	
1ST YEAR REQ'D_	NUMBER AVAILABLE _		· .
QUIPMENT UTILIZATION:		•	
FUNCTIONAL			
FLOW BLOCK NUMBER	Location Required	NUMBER REQUIRED	
FLOW BLOCK NUMBER			
FLOW BLOCK	REQUIRED TPF/KSC	REQUIRED 1	• .
FLOW BLOCK NUMBER	REQUIRED	REQUIRED	- -
FLOW BLOCK NUMBER	REQUIRED TPF/KSC	REQUIRED 1	- -
FLOW BLOCK NUMBER	REQUIRED TPF/KSC	REQUIRED 1	- -
FLOW BLOCK NUMBER	REQUIRED TPF/KSC	REQUIRED 1	- -
FLOW BLOCK NUMBER	REQUIRED TPF/KSC	REQUIRED 1	-

Engine Handling Kit

name:	ENGINE HANDLING	KIT		EQU	IPMENT NO. 132	
Functi	IONAL REQUIREMENT	(s):				
Provid	es hardware requi	red for hand	ling engine	during	removal from a	nd instal-
	onto stage.			:		
				<del></del>		· · · · · · · · · · · · · · · · · · ·
EQUIPM	ENT DESCRIPTION:		•			
Handli	ng plug, grame, e	nd shipping	container.	(GFE f	urnished with e	ngine.)
		<del></del>		1. 1.4		
0000	_		(pmc)	CON AND	DEVELOPMENT)	<del> </del>
COST	•	-0-	· · · · · · · · · · · · · · · · · · ·			
	<b>\$</b> _		(REC	JRRING/U	NIT)	
EQUIPM	ENT CATEGORY:	,				
	NEW	MODIFIED	<del></del>	AS	IS X GFE wit	h engine
1ST	YEAR REQ'D_	NUI	MBER AVAILA	BLE		_
EQUIPM	ENT UTILIZATION:	•			•	•
	FUNCTIONAL	T.O	Cation		NUMBER	
	FLOW BLOCK NUMBER		QUIRED		REQUIRED	•
		TPF	/KSC	t e	'n	
		PPF	/WTR		.1	•
				•		<del>-</del> .
		F8C	tory	•	1	•
	***************************************	_				
		- <del></del>	<del></del>	•		•
					, S <sup>2</sup> , y	
MOMAY	neournen	3.	-	m.r. ~~	n <b>e</b> -0-	
TOTAL	REQUIRED	J.	TU	TAL COS!	τ. φ	

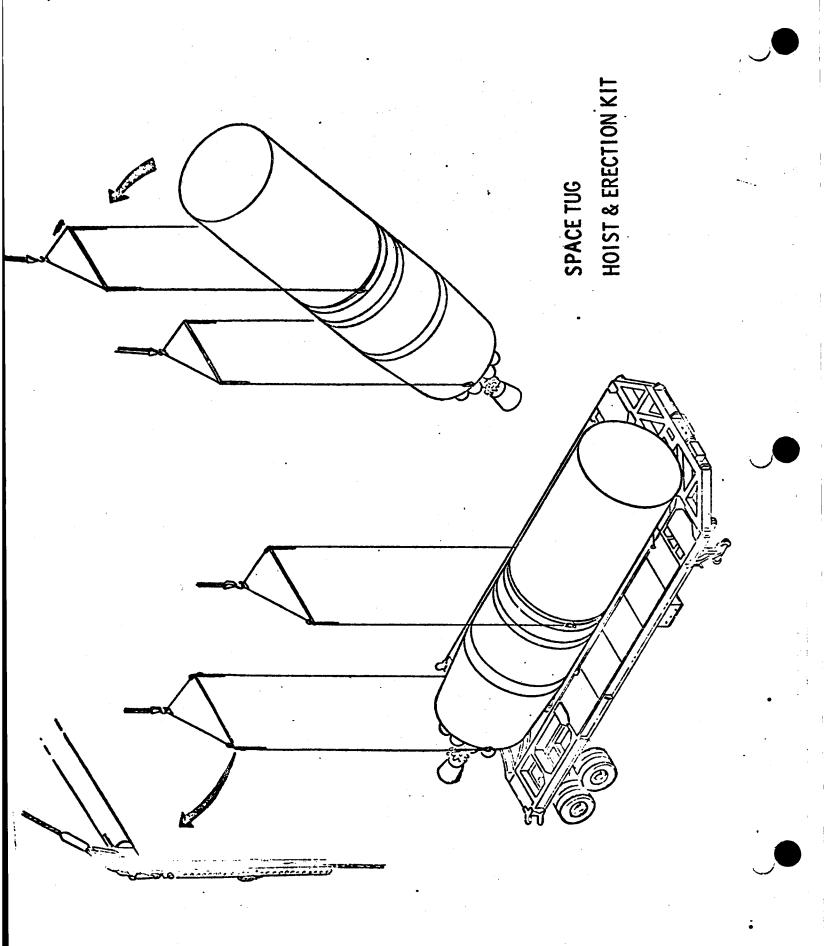


Calibration Fixture, Engine Position

NAME: ENGINE POSIT	CION C	ALIBRA	TION FIXT	JRE	EQUIPMENT NO. 133	
FUNCTIONAL REQUIRE	PENT (	(s):			•	
<b>Measures e</b> ngine geo			or with re	espect to the	heorectical stage o	enterline
for various position	ons of	the e	mgine.			<del></del>
	<del></del>					·
<i>f</i>						<del></del>
EQUIPMENT DESCRIPT	'ION:					
Similar to DSV-4B-0	529 <b>ar</b>	d DSV-	4B-699			
	·			<del></del>	•	
					······································	
				<del></del>		<del></del>
			<del></del>			
COST	\$	4,0	00	(DESIGN A	ND DEVELOPMENT)	
	\$	2,0	00	(RECURRING	J/WIT)	
EQUIPMENT CATEGORY	:					
NEWX	<del></del>	MOD	IFIED		AS IS	
18T YEAR REQ'D_		·	_ NUMBER	AVAILABLE _		
EQUIPMENT UTILIZAT	ION:				•	
Punctional Flow block Number		<b>.</b> -	LOCATIO REQUIRE		NUMBER REQUIRED	
1.1.9.2			TPF/KSC		1	
•			PPF/WTR		.1	
			Factory		1	
		•		·		
	<del></del>	•		•		
	<del></del>					
		. <del></del>	<del> </del>	-	<del></del>	•
TOTAL REQUIRED		2	· <u> </u>	TOTAL (	cost \$ 8,000	· ·

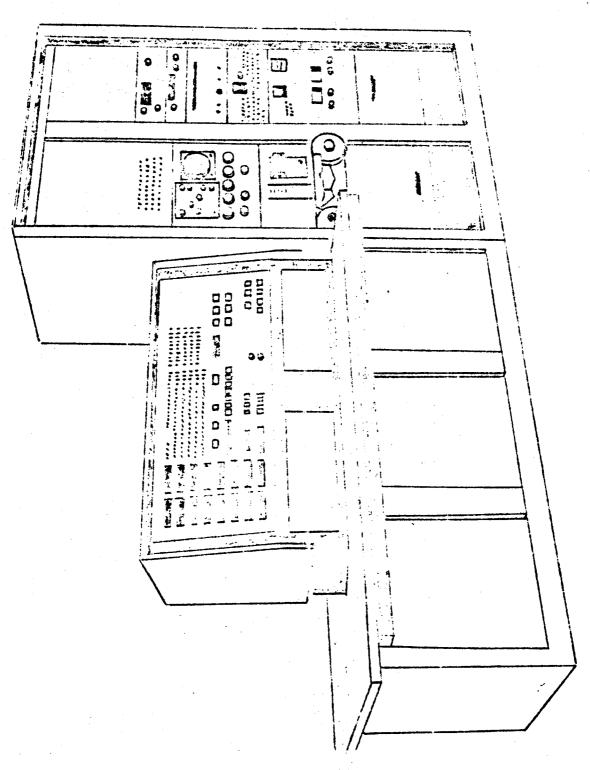
ME: EQUIPMENT VAN		
UNCTIONAL REQUIREMENT(	s):	
To provide for miscell	aneous transport	
· · · · · · · · · · · · · · · · · · ·		
<u> </u>		
QUIPMENT DESCRIPTION:		
1-1/2 ton two axle van	(Bob Tail) truck, GFE av	railable at facility.
COST \$_	(DESIGN	AND DEVELOPMENT)
\$	(RECURR	ING/UNIT)
\$ EQUIPMENT CATEGORY:	(RECURR	ING/UNIT)
\$ EQUIPMENT CATEGORY:		ING/UNIT)  AS IS X GFE
\$EQUIPMENT CATEGORY:		AS IS X GFE
\$EQUIPMENT CATEGORY:	MODIFIED	AS IS X GFE
\$EQUIPMENT CATEGORY:  NEW 1ST YEAR REQ'D	MODIFIED	AS IS X GFE
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK	MODIFIED NUMBER AVAILABLE LOCATION	AS IS X GFE  NUMBER
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER	MODIFIED NUMBER AVAILABLE LOCATION REQUIRED	AS IS X GFE  NUMBER
EQUIPMENT CATEGORY:  NEW  IST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER  (1.1.22	MODIFIEDNUMBER AVAILABLE LOCATION REQUIREDKSC	AS IS X GFE  NUMBER
EQUIPMENT CATEGORY:  NEW  IST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER  (1.1.22	MODIFIEDNUMBER AVAILABLE LOCATION REQUIREDKSC	AS IS X GFE  NUMBER
EQUIPMENT CATEGORY:  NEW  IST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER  (1.1.22	MODIFIEDNUMBER AVAILABLE LOCATION REQUIREDKSC	AS IS X GFE  NUMBER
EQUIPMENT CATEGORY:  NEW  IST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER  (1.1.22	MODIFIEDNUMBER AVAILABLE LOCATION REQUIREDKSC	AS IS X GFE  NUMBER

	EQUIPMENT		QUIPMENT NO	139
PUNCTIONAL REQUIREM	Ment(8):		•	
Verify acceptable	moisture content	of propellant s	ystems prior	to loading.
Verify safe levels	s of hazardous gas	concentrations	•	
<u> </u>				
QUIPMENT DESCRIPTI	ION:	•		
Moisture monitor,		ectors and anal	yzers.	
				<u> </u>
			·	
	·	<del></del>	· · · · · · · · · · · · · · · · · · ·	
OST	\$0	(DESIGN AND	D DEVELOPMENT	<b>!)</b>
	\$ 150	( RECURRING,	/UNIT)	
QUIPMENT CATEGORY:	***************************************		•	•
ACTIONI ONIDONI.	•			
MEN.	MARTETER		O TO **	
NEW			s is x	•
	MODIFIED NUMB		<u> </u>	•
18T YEAR REQ'D	numb		<u> </u>	•
1ST YEAR REQ'D	numb	ER AVAILABLE	<u> </u>	· .
18T YEAR REQ'D	numb Ion: Loca Requ	ER AVAILABLE	NUMBER	· .
18T YEAR REQ'D	NUMB LOCA REQU Safing	ER AVAILABLE	number Required	· .
18T YEAR REQ'D	NUMB LOCA REQU Safing	TION IRED Area/KSC e Prop/KSC	number Required	· .
18T YEAR REQ'D	NUMB LOCA REQU Safing Storable Portable	TION IRED Area/KSC e Prop/KSC	NUMBER REQUIRED 1	· .
1ST YEAR REQ'D	NUMB LOCA REQU Safing Storable Portable Safing	TION IRED Area/KSC e Prop/KSC	NUMBER REQUIRED  1  1	· .
18T YEAR REQ'D	NUMB LOCA REQU Safing Storable Portable Safing	TION IRED Area/KSC e Prop/KSC e/KSC Area/WTR e Prop/WTR	NUMBER REQUIRED	· .



E-64

NAME: HANDLING EQUIP	Vi≥N/AL	EQUIPMENT NO. 140	<del></del>
FUNCTIONAL REQUIREMENT	(ន):		
Provide means to hois	t and/or rotate Tug from eit	ther a horizontal or	vertical
attitude with either	one or two cranes as require	d.	
<u> </u>			
EQUIPMENT DESCRIPTION:			
Two wire sling and spr	reader bar assemblies with a	ppropriate shackle	fittings.
One assembly to be ad:	•		
COST \$_	25,000 (DESIGN A)	ND DEVELOPMENT)	
	5,000 (RECURRING	G/UNIT)	
EQUIPMENT CATEGORY:			
NEM X	MODIFIED	AS IS	
1ST YEAR REQ'D	NUMBER AVAILABLE	0	
EQUIPMENT UTILIZATION:	•	•	
Functional Flow Block Number	LOCATION REQUIRED	number R <b>e</b> quired	
2.1.3	Pad/KSC	2	
2.2.1.2	MCF/KSC	11	
2.2.3	TPF/KSC	1	
2.3.6	Pad/WTR	2	•
2.4.5, 2.4.8	MCF/WTR	1	
•	PPF/WTR	1	
POTAL REQUIRED	8 TOTAL C	osr \$ 65,000	



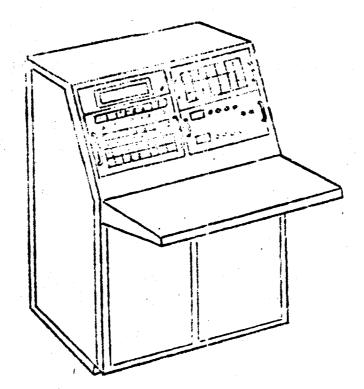
GUIDANCE AND NAVIGATION TEST SET

URATION	OPTION

RAME: GUIDANCE AND N	AVIGATION TEST SET	EQUIPMENT NO. 142
FUNCTIONAL REQUIREMENT	r(s):	
Monitors and verifies	checkout of IMU and GC	. It provides calibration,
		ams. Capable of simulations of
all flight programs.		
EQUIPMENT DESCRIPTION:		
* · · · · · · · · · · · · · · · · · · ·		ich include display panel, control
		tal voltmeter, interface (DIU) ass
		unch, test point control panel, do
	etc. (Available from De	
COST FER UNIT: \$_	-0- (NOII-	RECURRING)
\$	-0- (RECU	URRING/YEAR)
EQUIPMENT CATEGORY:	,	
NEW	MODIFIED	· AS IS X GFE
	NUMBER AVAILA	
EQUIPMENT UTILIZATION		
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	Number Required
1.1.13	KSC '	1/
	WTR	1/
made of many and the second se	Factory	1
TOTAL REQUIERED	3 T(	otal cost \$ -0-
TOTAL REQUIRED	<u> </u>	OTAL COST \$

CONFIGURATION	OPTION
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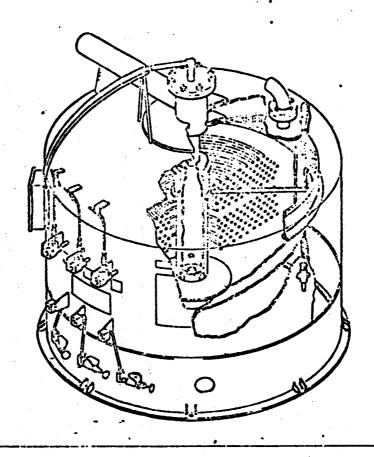
			,	r no	T-2)
ment(s)	:			.•	·
Tug IM	MU and GC and t	he labora	tory test	equipmen	t. Also
of IMU	to rate table.				
					<del></del>
					·
-				<del></del>	<del></del>
lding f	ixture and cab	les.			
				<del></del>	
				<del></del>	
					-
		•			-
				•	·•
\$	-0-	(RECURRIN	NG/YEAR)		
:				•	
	NUMBER A	AVAILABLE			•••
ON:			•		
	KSC		1		<u>.</u>
·	WTR		1		_
	Factory		1	,	<del>-</del>
	<del></del>				•
		<del></del>	<del></del>		•
					_
	3	መረስ ል ፕ	coan ¢	0_	
	Tug IN of IMU ION: lding f lta Pro	of IMU to rate table.  ION:  Iding fixture and cab  Ita Program.)  \$O  \$O  MODIFIED  NUMBER A  ION:  LOCATION REQUIRED  KSC  WTR	Tug IMU and GC and the labora of IMU to rate table.  ION: Iding fixture and cables.  Ita Program.)  \$O_ (NON-RECURRIN  MODIFIED	Tug IMU and GC and the laboratory test of IMU to rate table.  ION: Iding fixture and cables.  Ita Program.)  \$O_ (NON-RECURRING)  \$O_ (RECURRING/YEAR)  MODIFIED AS IS  NUMBER AVAILABLE  ION:  LOCATION NU REQUIRED REQUIRED  KSC 1  WTR 1  Factory 1	Tug IMU and GC and the laboratory test equipmen of IMU to rate table.  ION: Iding fixture and cables.  Ita Program.)  \$O (NON-RECURRING)  \$O (RECURRING/YEAR)  MODIFIED AS IS X GFE  NUMBER AVAILABLE  ION:  LOCATION REQUIRED  REQUIRED  KSC 1  WTR 1  Factory 1



LAUNCH COUNTDOWN CONSOLE

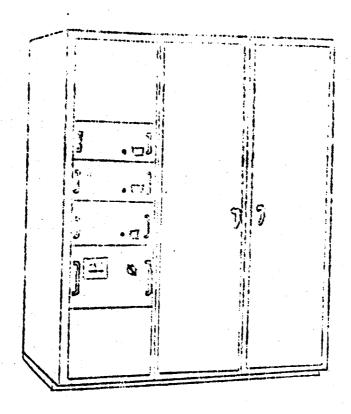
CONFIGURATION	OPTION

NAME: LAUNG	CH COUNT DO	WN CONSOLE		EQUIPMENT NO. 145
FUNCTIONAL REGU	Jirement(s)	:		
Controls and	monitors la	unch checkout	and count	down of Tug vehicle.
			:	
EQUIPMENT DESCR				
Console with	intercom an	d count down	clock, sta	tus indicators, alpha
mmerical dis	play and as	sociated circ	uitry.	
			<del> </del>	
COST	\$	30,000	(DESIGN	AND DEVELOPMENT)
	<u></u>	20,000	-	ING/UNIT)
POLITOLONIN CAREC	Ψ		(1000000	
EQUIPMENT CATEO		MANTETEN		110.70
	X	MODIFIED		AS IS X GFE at ETR
		NUMBER	AVAILABLE	
EQUIPMENT UTILI FUNCTIO		•	4 V	
FLOW BI NUMBER	LOCK	LOCATION REQUIRE		NUMBER REQUIRED
2.4.	3	KSC		2
2.4.	4	WTR	•	1
	<del></del>		·	
				·
	<del></del>	<del></del>		
<del></del>		-		
		<del> </del>		
TOTAL REQUIRED	<del></del>		TOTAL	COST \$ 50.000



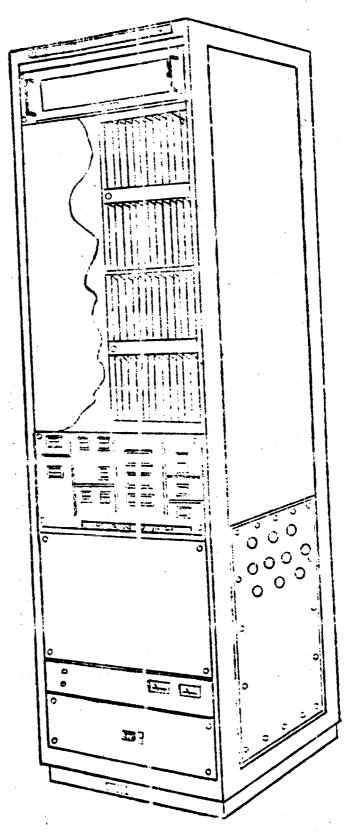
LH - HEAT EXCHANGER

NAME: LH2-He HE	AT EXC	HANGER	·	EQUIPMENT NO. 147	
FUNCTIONAL REQUIRE	ment (s	s):			
Provide prechill	ing of	helium used fo	or APS tar	nk pressurization or main	
propellant tank	pressu	rization			
<i>t</i>					
EQUIPMENT DESCRIPT	'ION:				
_		utilizing hardw	are from	Sacramento Test Center a	nd
KSC where possib	le.		<del> </del>		
<del>""</del>			·····		
Cort	\$	0	(DESIGN AND DEVELOPMENT) (RECURRING/UNIT)		
	\$	20,000			
EQUIPMENT CATEGORY	<b>:</b>				
NEW		MODIFIED X	<del></del>	AS IS	
1ST YEAR REQ'D_	· · · · · · · · · · · · · · · · · · ·	NUMBER	AVAILABI	Æ	
EQUIPMENT UTILIZAT	CION:			•	
Functional Flow block Number		LOCATI REQUIR		NUMBER REQUIRED	
1.1.8.2	-	KSC		2	
1.1.9.7		WTR		1	
			·		·
<del></del>	<del></del>				
<del></del>	<del></del>	<del></del>			
	<del></del>	**************************************	'/		
TOTAL REQUIRED	-	3	TOTA	AL COST \$ 60,000	•



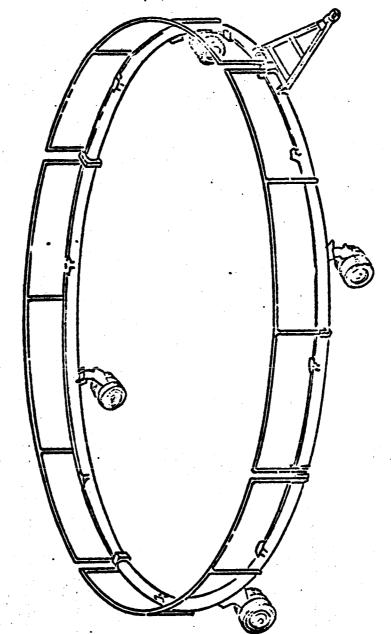
SIGNAL CONDITIONING UNIF

NAME: SIGNAL CONDITIONI	NG UNIT	EQUIPMENT NO. 11	18
FUNCTIONAL REQUIREMENT(S):			
Interfaces between Tug veh	icle and GSE for signa	l and power condition	oning, and
distribution			
<u> </u>			
EQUIPMENT DESCRIPTION:			
Consists of a 3 bay consol	e which contains junct.	ion box, (1) 1032 po	oint patch panel
assembly, (10) isolation a			
(1) logic power supply, an	<del></del>		
DSV-4B-133).		•	
COST \$	300,000 (DESIGN	AND DEVELOPMENT)	
\$	120,000 (RECURR	ING/UNIT)	
EQUIPMENT CATEGORY:			
NEM x	MODIFIED	AS IS	
1ST YEAR REQ'D	NUMBER AVAILABLE	ē	_
EQUIPMENT UTILIZATION:		•	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
1.1.5	TPF/KSC	1	_
1.1.7 ALL	MCF/KSC	1	_
/ 1.1.8 ALL	PPF/WTR	1	_
2.3.9	MCF/WTR	1	-
2.4.3	Launch Pad/KSC	2	<b>-</b>
	Factory	<u> </u>	
TOTAL REQUIRED	7TOTA	L COST \$ 1,140,00	0
•			



ORBITER SIMULATOR

NAME: ORBITER SI	MULATO	R	EQUIPMENT NO. 149
FUNCTIONAL REQUIRE	ment (s	):	
Functionally sim	ulates	orbiter/Tug int	erfaces for verification of electrical
parameters			
<i>f</i>			
EQUIPMENT DESCRIPT	ION:		
•		aining encoder,	decoder and load test circuits.
Contains switche	s and	indicator lights	
	•		
COST \$		400,000	(DESIGN AND DEVELOPMENT)
	\$	100,000	(RECURRING/UNIT)
EQUIPMENT CATEGORY	·:		
NEW	<del></del>	MODIFIED	AS IS
1ST YEAR REQ'D_		NUMBER A	AVAILABLE
EQUIPMENT UTILIZAT	'ION:		•
Functional Flow block Number		LOCATION REQUIRES	
1.1.7.9		TPF/KSC	1
1.1.8.9		PPF/WTR	1
1.1.9.9		Factory	1
		· .	
TOTAL REQUIRED		2	TOTAL COST \$ 700,000



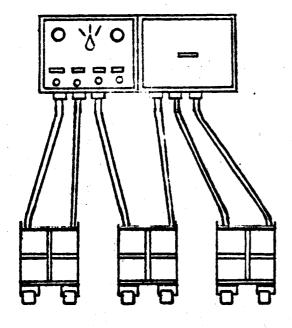
PAYLOAD ADAPTER HANDLING KIT

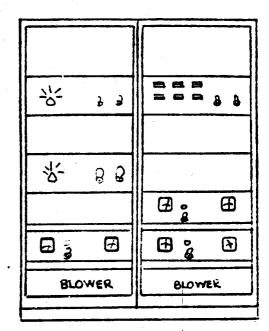
NAME: PAYLOAD ADAI	ME: PAYLOAD ADAPTER HANDLING KIT			EQUIPMENT NO. 150			
FUNCTIONAL REQUIRE	MENT (S	3):			•	•	
Provides protection	and r	neans o	of handlin	g payload	inte	rface unit.	
<u> </u>		٠.					•
EQUIPMENT DESCRIPT	ION:						
Similar to DSV-4B-3	352		·				
				`			
Cost	\$	10.0	00	(DEGTOW			
COS1	· · · · · · · · · · · · · · · · · · ·	10,0		(DESIGN AND DEVELOPMENT)			
	\$	5,0	00	(RECURRI	IG/UN:	IT)	
EQUIPMENT CATEGORY							
NEW_X		MODI	FIED		AS :	IS	
1ST YEAR REQ'D_	<del> </del>	<del> </del>	NUMBER A	AVAIIABLE			
EQUIPMENT UTILIZAT							
Functional Flow block Number		•	LOCATIO:			NUMBER REQUIRED	
2.2.3	<del></del>	, ,	TPF/KS	C		1	
			PPF/KS	C		1	
****	•		PPF/WT	R		1	
				·	***		
			<del></del>	· · · · · · · · · · · · · · · · · · ·			
	<del></del>	_		<del></del>			
TOWAT DECUTORS		-	7			05.000	
TOTAL REQUIRED		3		TOTAL	Cost	\$ 25,000	

NAME: PERSONNEL PROTEC	TION EQUIPMENT	EQUIPMENT NO. 15	2
FUNCTIONAL REQUIREMENT	(s):		<del></del>
Provide environmental	protection for si	torable APS loading crew.	
	proveduou for a	orable ard loading crew.	
			<del></del>
	·		-
<i>.</i>	· · · · · · · · · · · · · · · · · · ·		
QUIPMENT DESCRIPTION:			
-	hwaething devices	, and fire equipment. SCAP	T milto
	or egoning devices	, and the equipment. Some	B Bulls,
if required.			
<del>-</del>			
	· · · · · · · · · · · · · · · · · · ·		
		•	
CORT \$_	0	(DESIGN AND DEVELOPMENT)	•
<b>\$</b>	4000	(RECURRING/UNIT)	
QUIPMENT CATEGORY:	en en en en en en en en en en en en en e		
NEW	MODIFIED	AS IS X	
18T YEAR REQ'D	NUMBER A	AILABLE	
QUIPMENT UTILIZATION:		tana di Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Ka Kabupatèn Kabupatèn	
FUNCTIONAL FLOW BLOCK	LOCATION	NUMBER	
NUMBER	REQUIRED	REQUIRED	
2.1.7	KSC	ls .	
*	WTR	· h	-
	WIR	4	
		<del></del>	-
			-

CONFIGURATION OPTION
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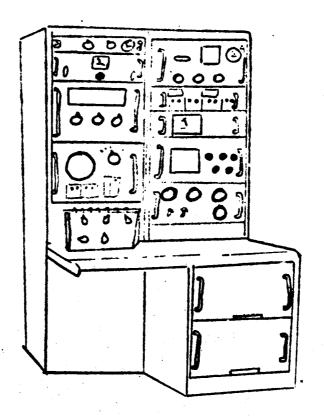
NAME: PREUMATIC CO	ONSOLE .	ACPS PORTABLE T	EST SET E	DUIPAFNT NO. 153		
FUNCTIONAL REQUIR	ement (S	3):			,	
Manually checks e	lectric	al continuity o	f solenoid v	valves talkback and actuati	on	
of solenoid valve		•				
or solehold valve	3, p. cs	<u> </u>				
				·	<del></del>	
			,		,	
EQUIPMENT DESCRIP	TION:					
Similar to DSV-4B	-286 an	d 286A	·			
	·,		·			
COST \$		76,000	(DESIGN A	ND DEVELOPMENT)		
	\$	28,000	(RECURRIN	(RECURRING/UNIT)		
EQUIPMENT CATEGOR	Y:					
NEW_X		MODIFIED_		AS IS		
1ST YEAR REQ'D		NUMBER NUMBER	AVAILABLE _			
EQUIPMENT UTILIZA	TION:		. **			
Functional Flow block Number		LOCATION REQUIRED		NUMBER REQUIRED		
2.1.7		KSC STORABLE		1		
		WTR STORABLE		.1		
			ORY	1		
				•		
			<del></del>			
***	<del></del>	-				
		**************************************	· · · · · · · · · · · · · · · · · · ·			
TOTAL REQUIRED	<del></del>	3	TOTAL (	COST \$ 160,000	·.	





POWER SYSTEM TEST SET

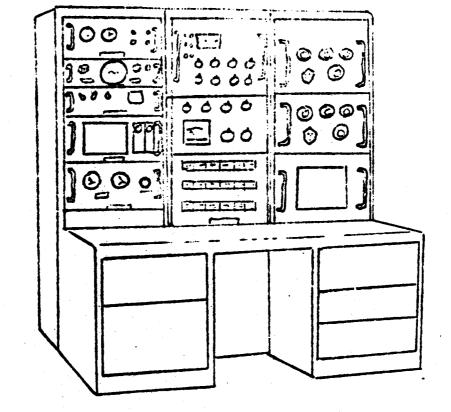
NAME: POW	er system	T/S (PSTS	)		E	QUIPMENT NO	155	
<b>FUNCTIONAL</b>	REQUIREME	nt(s):		•				
Provide me	ans to los	d fuel ce	lls and	vehicle	power	distribution s	system.	Provide
ground pow	er sources	for vehi	cle and	GSE. Pr	ovide	emergency power	er in ev	rent
facility p	ower malfu	netion.			•			
<u> </u>							<del></del>	
EQUIPMENT :	DESCRIPTIO	);;			<del></del>			
•			uipment	containi	ng tw	o independent p	rogram	able power
						supply for GSE		<del></del>
					<del></del>	backup battery		
for emerge		<del>_ , , ,</del>						-
						· · · · · · · · · · · · · · · · · · ·	- <del></del>	
COST FER U	NIT:	\$ 13	4,000	(non-	-recur	RING)	• .	
•		\$	8,000	(REC	JRRING	(YEAR)		
EQUIPMENT	CATEGORY:							
new_	х	MOD	IFIED_			AS IS	•	
1ST YEAR	REQ'D_		_ NUMB	ER AVAIL	ABLE _		<del></del>	
EQUIPMENT	UTILIZATIO	n:				•		
FL	NCTIONAL OW BLOCK UMBER			TION IRED		NUMBER REQUIRED		
-	1.1.5, 1.	1.7 ALL	TPF/KS	<u>c                                      </u>		<u> </u>		
/	1.1.8 ALL	1.1.9 ALI	MCF/KS	C		1		•
-	2.3.9, 2.	4.2	PPF/WI	R		1		
•	2.4.3		MCF/WI	R		1		
			Launch	Pad/ETR		2		
			Factor			1!		
TOTAL REQU	JIRED	7		η·	OPAT. (	COST \$ 470	0,000	



PRINTED CIRCUIT CARD COMPONENT TEST SET

CONFIGURATION	OPTION	
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AME: PRINTED CI	RCUIT CA	RD COMPONENT TE	EST SET EQUIPMENT NO. 157
unctional requi	remen <b>t</b> (s	;):	
Tests printed	circuit	cards and isolat	ates difficulties to component level.
			d loads. Monitors outputs of cards
4	_		
EQUIPMENT DESCRIP			
Similar to DSV-			
		**************************************	
**************************************			
	<del> </del>		
:07T	\$	39,200	(DESIGN AND DEVELOPMENT)
	\$	53,000	(RECURRING/UNIT)
QUIPMENT CATEGOR	Υ:		
NEW		MODIFIED 20%	AS IS 80%
18T YEAR REQ'D_		NUMBER A	AVAILABLE
QUIPMENT UTILIZA	TION:		•
Functiona Flow bloc Number		LOCATION REQUIRED	***************************************
	<del></del>	Factory	1
•			
-	<del></del>		
<u> </u>		***************************************	
OTAL REQUIRED		1	TOTAL COST \$ 92,000



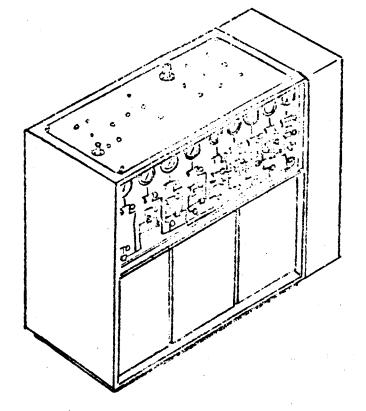
PROPELLANT UTILIZATION COMPONENT TEST SET

CONFIGURATION	OPTION	
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Office TOWN Wise	irement (s)	:	
Tests and cal	ibrates P.U	J. electronics as	ssembly adjustments.
<del></del>			
<del></del>			
<u>/</u>			
EQUIPMENT DESCR	IPTION:		
Similar to DS	V-4B-112	·	
	<u> </u>	3.07 (00	(
Cort	<u> </u>	121,600	(DESIGN AND DEVELOPMENT)
	4	_	
	\$	56.000	(RECURRING/UNIT)
EQUIPMENT CATEG	` <del></del>	56,000	(RECURRING/UNIT)
	ORY:		(RECURRING/UNIT)  AS IS 80% ETR
NEW_X	ORY:	MODIFIED 20%	
NEW X	WTR	MODIFIED 20%	AS IS 80% ETR
	WTR D ZATION: DNAL LOCK	MODIFIED 20%	AS IS 80% ETR
NEW X  1ST YEAR REQUIPMENT UTILITY  FUNCTION FLOW BL	WTR D ZATION: DNAL LOCK	MODIFIED 20%  NUMBER AV  LOCATION	AS IS 80% ETR VAILABLE
NEW X  1ST YEAR REQUIPMENT UTILI  FUNCTION FLOW BIANDER	WTR D ZATION: DNAL LOCK	MODIFIED 20%  NUMBER AV  LOCATION REQUIRED	AS IS 80% ETR VAILABLE  NUMBER REQUIRED
NEW X  1ST YEAR REQUIPMENT UTILI  FUNCTION FLOW BIANUMBER  1.1.8	WTR D ZATION: DNAL LOCK	MODIFIED 20%  NUMBER AV  LOCATION REQUIRED  TPF/KSC	AS IS 80% ETR VAILABLE  NUMBER REQUIRED
NEW X  1ST YEAR REQUIPMENT UTILI  FUNCTION FLOW BIANUMBER  1.1.8	WTR D ZATION: DNAL LOCK	MODIFIED 20%  NUMBER AV  LOCATION REQUIRED  TPF/KSC  PPF/WTR	AS IS 80% ETR  VAILABLE  NUMBER REQUIRED  1
NEW X  1ST YEAR REQUIPMENT UTILI  FUNCTION FLOW BIANUMBER  1.1.8	WTR D ZATION: DNAL LOCK	MODIFIED 20%  NUMBER AV  LOCATION REQUIRED  TPF/KSC  PPF/WTR	AS IS 80% ETR  VAILABLE  NUMBER REQUIRED  1

CONFIGURATION	OPTION	

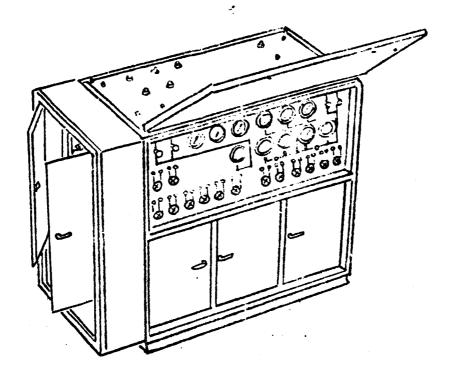
MAME: PROPULSION COM	PONENT REPAIR KIT	EQUIPAENT NO. 160
Functional Requirement	r(s):	
Provides equipment nec	cessary for disassembly,	repair, re-assembly, and test
of propulsion componer		
EQUIPMENT DESCRIPTION:		
	tools, adapters, and other	er equipment.
CONT \$_	2,000 (DESIG	H AND DEVELOPMENT)
<b>.</b>	10,000 (RECUR	RING/UNIT)
EQUIPMENT CATEGORY:		
New_x	MODIFIED	AS IS
18T YEAR REQ'D	NUMBER AVAILABI	
QUIPMENT UTILIZATION:		•
Punctional Plow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
<u>/-1.1.12</u>	KSC	1
	WTR	1.
	Factory	1
	•	
	· Control of the cont	



PROPULSION PHEUMATIC CONSOLE (CHECKOUT)

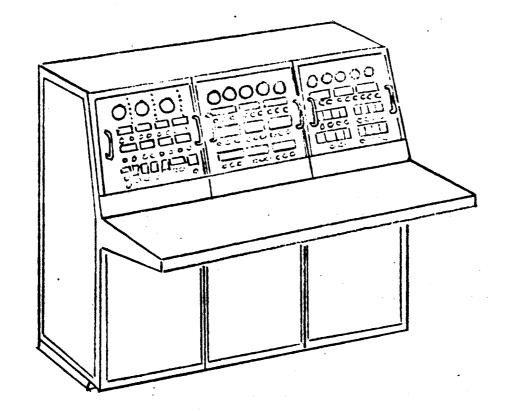
CONFIGURATION OPTION	ION OPTION
----------------------	------------

NAME: PREUMATIC SKID C	BECKOUT	EQUITMENT NO. 161
FUNCTIONAL REQUIREMENT(S	<b>)</b> :	
Provide regulated gas sub	plies to vehicle for pre	ssurization of pneumatic and
		checks, purging, pressure
		enecks, purging, pressure
draining, and application	of blanket pressures.	
	·	
EQUIPMENT DESCRIPTION:		
Pneumatic console such as	DSV-4B-321 modified as	required for special Tug
requirements.		<del></del>
COST FER UNIT: \$	50,000 (MON-REC	CURRING)
<b>\$</b>	450,000 (RECURR)	ing/year)
EQUIPMENT CATEGORY:		
NEW X WTR	MODIFIED	AS IS X ETR
1ST YEAR REQ'D_	NUMBER AVAILABLE	7
EQUIPMENT UTILIZATION:		
Punctional Plow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
1.1.7.14	TPF/KSC	1 GFE
1.1.7, 6-9	PPF/WTR	
1.1.8 ALL	Factory	1 GFE
1.1.9 ALL	MCF/KSC	1 GFE
	MCF/WTR	1
		•
<del></del>	<del></del>	
TOTAL REQUIRED	5 TOTAL	COST \$ 950,000



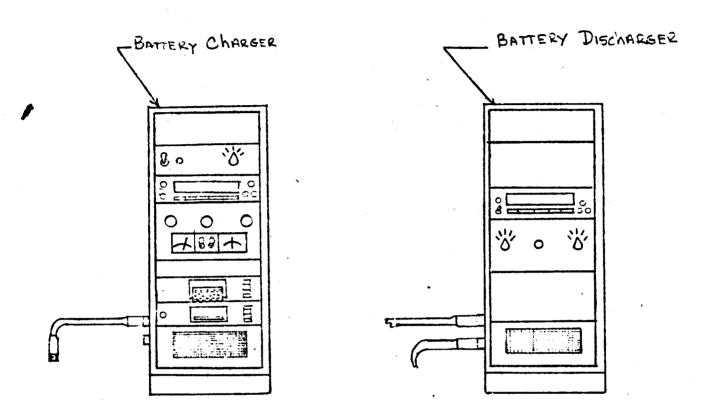
PROPULSION PHEUMATIC CONSOLE (LAUNCH)

AME: PHEUMATIC	SKID LAUNCH	EQUIPMENT NO. 162
unctional requir	ement(s):	
Provide regulate	ed gas supplies to vehicle	for pressurization of pneumatic
	systems for pad checkout an	
and propertant	systems for pad checkout an	a Isunca.
<u> </u>		
QUIPMENT DESCRIPT	Tion:	
		fied for special Tug requirements.
	TO SECTION OF THE PROPERTY AND ADDRESS OF THE PROPERTY ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY ADDRESS OF THE PROPERTY AND ADDRESS OF THE PROPERTY ADD	Tite 101 Special 148 164411 cannot
OST	\$ 50,000 (DE	SIGN AND DEVELOPMENT)
	\$ 450,000 (RE	ECURRING/UNIT)
QUIPMENT CATEGORY	Y:	
NEW X WI		'AC TO V CHE EMP
	<del></del>	AS IS X GFE ETR
1ST YEAR REQ'D_	NUMBER AVAI	LABLE
QUIPMENT UTILIZAT	rion:	· · · · · · · · · · · · · · · · · · ·
FUNCTIONAL		NUMBER
FLOW BLOCK NUMBER	PENITOEN	REQUIRED
2.4.2		
	Launch Area/KSC	
2.4.3	Launch Area/WTR	



PROPELLANT OR PNEUMATIC CONTROL CONSOLE

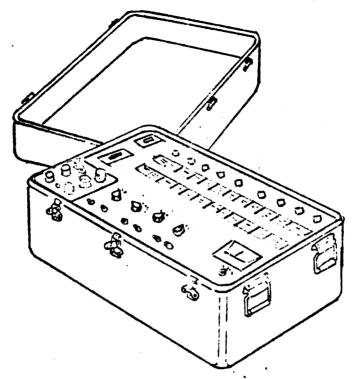
FUNCTIONAL REQUIREMENT(S	s):			
ntrols and pneumatic reg	ulated gas supplies fo	r vehicl	e pressurization of	
cumatics and propellant		<del></del>		heck
d loading of pneumatics				
ading. Capable of semi-	<del></del>	<del></del>		
	encometic of Walder To	ading of	propertants.	
EQUIPMENT DESCRIPTION:				
Three bay console with in	<del></del>			l 
numerical display, and a	ssociated circuitry.	(Similar	to DSV-4B-233.)	
		·		
			·	:
•	339,000 (NON-F 334,000 (RECUI		r)	
\$	MODIFIED	ring/ye/ As i	s X etr	
EQUIPMENT CATEGORY:  NEW X WTR  1ST YEAR REQ'D	MODIFIED	ring/ye/ As i		
\$	MODIFIED	ring/ye/ As i		
EQUIPMENT CATEGORY:  NEW X WTR  LST YEAR REQ'D  EQUIPMENT UTILIZATION:  PUNCTIONAL PLOW BLOCK	MODIFIED NUMBER AVAILAB	ring/ye/ As i	S X ETR	
EQUIPMENT CATEGORY:  NEW X WTR  LST YEAR REQ'D  EQUIPMENT UTILIZATION:  PUNCTIONAL PLOW BLOCK NUMBER	MODIFIEDNUMBER AVAILABE LOCATION REQUIRED	ring/ye/ As i	S X ETR  NUMBER  REQUIRED	
EQUIPMENT CATEGORY:  NEW X WTR  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  PUNCTIONAL PLOW BLOCK NUMBER  1.1.7.1,4	MODIFIEDNUMBER AVAILAE  LOCATION REQUIRED TPF/KSC	ring/ye/ As i	S X ETR  NUMBER  REQUIRED  1 GFE	
EQUIPMENT CATEGORY:  NEW X WTR  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  PUNCTIONAL PLOW BLOCK NUMBER  1.1.7.1,4  /1.1.7.6 - 9	MODIFIED  NUMBER AVAILAB  LOCATION REQUIRED  TPF/KSC  Launch Pad/KSC	ring/ye/ As i	S X ETR  NUMBER REQUIRED  1 GFE  - 2 GFE	
EQUIPMENT CATEGORY:  NEW X WTR  LST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.7.1,4  /1.1.7.6 - 9  /1.1.8 ALL	MODIFIED  NUMBER AVAILABE  LOCATION REQUIRED  TPF/KSC  Launch Pad/KSC  PPF/WTR	ring/ye/ As i	NUMBER REQUIRED  1 GFE  - 2 GFE	
EQUIPMENT CATEGORY:  NEW X WTR  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  PUNCTIONAL PLOW BLOCK NUMBER  1.1.7.1,4  /1.1.7.6 - 9  /1.1.8 ALL  1.1.9 ALL	MODIFIED  NUMBER AVAILABE  LOCATION REQUIRED  TPF/KSC  Launch Pad/KSC  PPF/WTR  MCF/KSC	ring/ye/ As i	NUMBER REQUIRED  1 GFE  2 GFE  1 GFE	



BATTERY CHECKOUT KIT

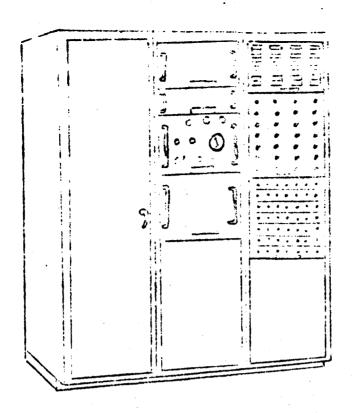
CONFIGURA	TION	OPTION		

NAME: BATTERY CHECKO	UT KIT	EQUIPMENT NO. 16	54
FUNCTIONAL REQUIREMENT(	s):		
Provide equipment requi	red to checkout primary	and/or rechargeable b	atteries.
Battery activation, cel	1/battery voltage and co	urrent checks with/wit	hout load
(or during charging).	Provide heater power me	asure, heater current,	and battery
temperature.			
	rm; two electronic equi	pment racks, test cabl	
	eters line printer and		
		sequencer for automat.	te operation
(similar to DSV-48-171)		•	
COST PER UNIT: \$\$	50,000 (NON-R		
EQUIPMENT CATEGORY:			•
NEW	MODIFIED X	AS IS X GFE	
1ST YEAR REQ'D_	NUMBER AVAILAR	DLE	4.
EQUIPMENT UTILIZATION:		•	
Functional Flow Block Number	LOCATION REQUIRED	NUMBER RFQUIRED	
1.1.13	KSC (TPF)	1	• .
	WTR (PPF)	1	•
			<b>.</b>
•			· . •
TOTAL REQUIRED	2 <u>To</u>	TAL COST \$ 50,000	



SPACECRAFT SIMULATOR

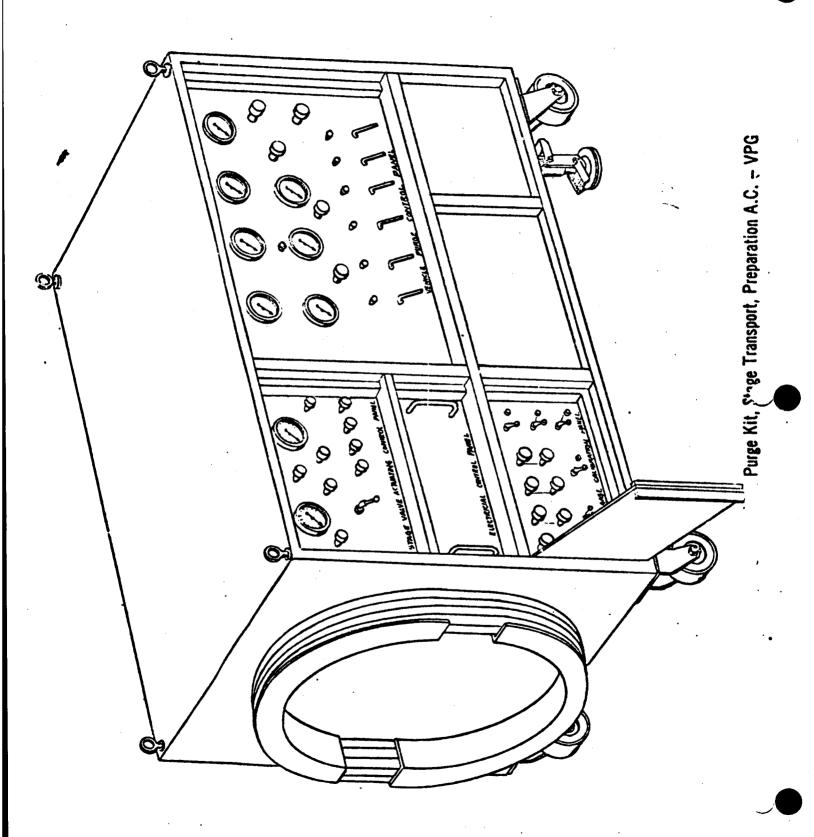
	ATOR	EQUIPMENT NO. 168	-
UNCTIONAL REQUIREMENT(	(s):		
•		face for verification of	
<u> </u>			
electrical parameters.	·		<del></del> -
	<del></del>	<del></del>	
<b>,</b>			
QUIPMENT DESCRIPTION:			
	ining encoder. decoder	and load test circuits.	
OST \$	150,000 (DE	SIGN AND DEVELOPMENT)	
Uii 1		CURRING/UNIT)	
<b>\$_</b> _	50.000 (RE	CORRERRY ON II )	
QUIPMENT CATEGORY:	•		
NEWx	MODIFIED	AS IS	
	····-		
1ST YEAR REQ'D	NUMBER AVAII	ABLE	
	NUMBER AVAII		
1ST YEAR REQ'D_CQUIPMENT UTILIZATION:		ABLE	
QUIPMENT UTILIZATION: FUNCTIONAL FLOW BLOCK	NUMBER AVAII  LOCATION REQUIRED		
QUIPMENT UTILIZATION: FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	ABLE	
QUIPMENT UTILIZATION: FUNCTIONAL FLOW BLOCK NUMBER 1.1.7.9	LOCATION	NUMBER REQUIRED	
QUIPMENT UTILIZATION: FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	ABLE	
QUIPMENT UTILIZATION: FUNCTIONAL FLOW BLOCK NUMBER 1.1.7.9	LOCATION REQUIRED TPF/KSC	NUMBER REQUIRED	
QUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.7.9 1.1.8.9	LOCATION REQUIRED TPF/KSC PPF/WTR	NUMBER REQUIRED	
QUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.7.9 1.1.8.9	LOCATION REQUIRED TPF/KSC PPF/WTR	NUMBER REQUIRED	
QUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.7.9 1.1.8.9	LOCATION REQUIRED TPF/KSC PPF/WTR	NUMBER REQUIRED	



SPACE TUG SIMULATOR

OCIAL TO CITE TO THE COLUMN TO	CONF	IGUR	ATION.	OPTION	
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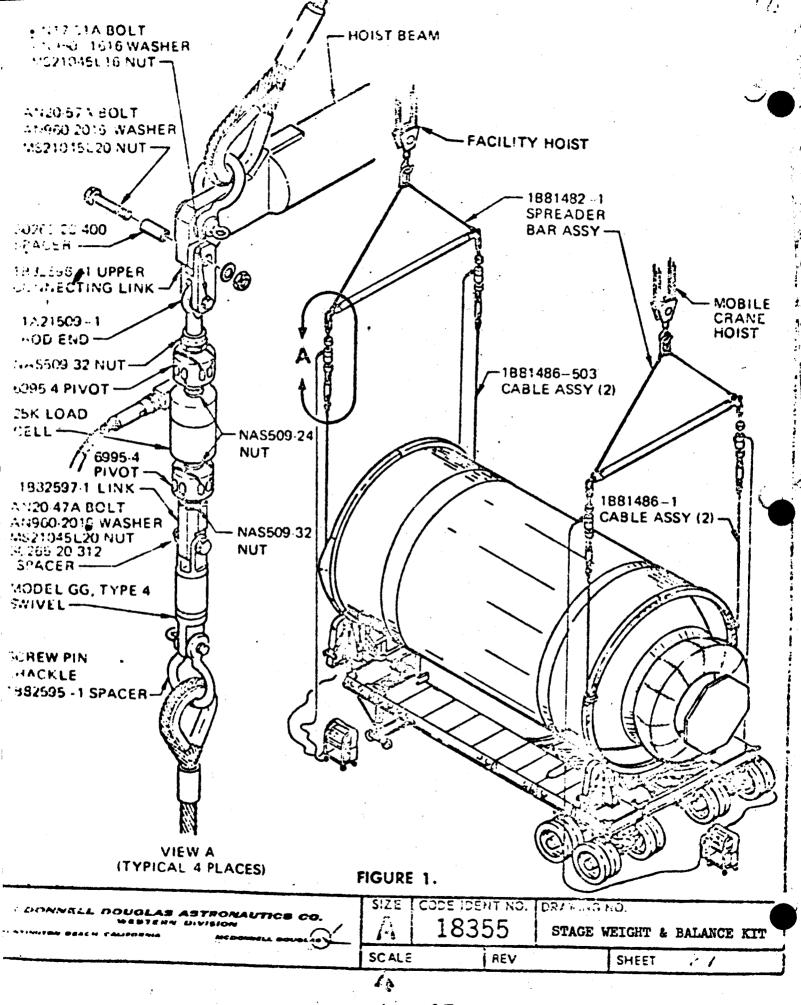
NAME: SPACE TUG SIM	ULATOR	EQUIPMENT NO. 169	
FUNCTIONAL REQUIREMENT	(s):		
Functionally simulate	s Tug electrical paramet	ers for verification of	of GSE, payload
and Shuttle interface			
1			
EQUIPMENT DESCRIPTION:		•	
3 Bay console inter	facing with computer con	plex containing logic	cards, encoder
	t test point assembly.	A.	
	o DSV-4B-132).		
Dath Daner (Similar L	0 101 10-10-10-10-10-10-10-10-10-10-10-10-10-1		
COST \$_	400,000 (DESI	GN AND DEVELOPMENT)	
\$_	100,000 (RECU	RRING/UNIT)	
EQUIPMENT CATEGORY:			
NEW_x	MODIFIED 30%	AS IS 70%'	
1ST YEAR REQ'D	NUMBER AVAILA	BLE	•
EQUIPMENT UTILIZATION:	•	•	
Functional Flow block Number	LOCATION REQUIRED	NUMBER REQUIRED	
1.1.7.9	TPF/KSC	1	•
1.1.8.9			•
1.1.9.9	PPF/WTR	1	•
			•
	Factory	1	
			•
TOTAL REQUIRED		TAL COST \$ 700,000	
TOTAL REQUIRED	3TO	TAL COST \$ 100,000	



F-100

CONFIGURATION	OPTION
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NAME: STAGE TRANSPORT PREP	ARATION GN PURGE UN	IT EQUIPMENT NO. 17	2
FUNCTIONAL REQUIREMENT(S):			
Purges propellant system t	o an acceptable leve	l for ground air tran	sport, maintains
proper nitrogen pressure a	t a level acceptable	for stage purge and	dry operation,
provides the required valv	e actuation to prote	ct the stage from adv	erse internal
pressures.			
EQUIPMENT DESCRIPTION:			
Utilize DSV-4B-1865			
<del></del>		•	
COST \$		GN AND DEVELOPMENT)	
\$	-0- (RECU	RRING/UNIT)	
EQUIPMENT CATEGORY:			
NEW	MODIFIED	AS IS 100%	
1ST YEAR REQ'D	NUMBER AVAILA	BLE	
EQUIPMENT UTILIZATION:	•	•	
Functional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED	
	. KSC	1	
		•	
	-	<del></del>	<del></del>
			-
<del></del>	<del></del>	<del></del>	· ·
TOTAL REQUIRED	1 TO:	ral cost \$	<del>umaine a</del>

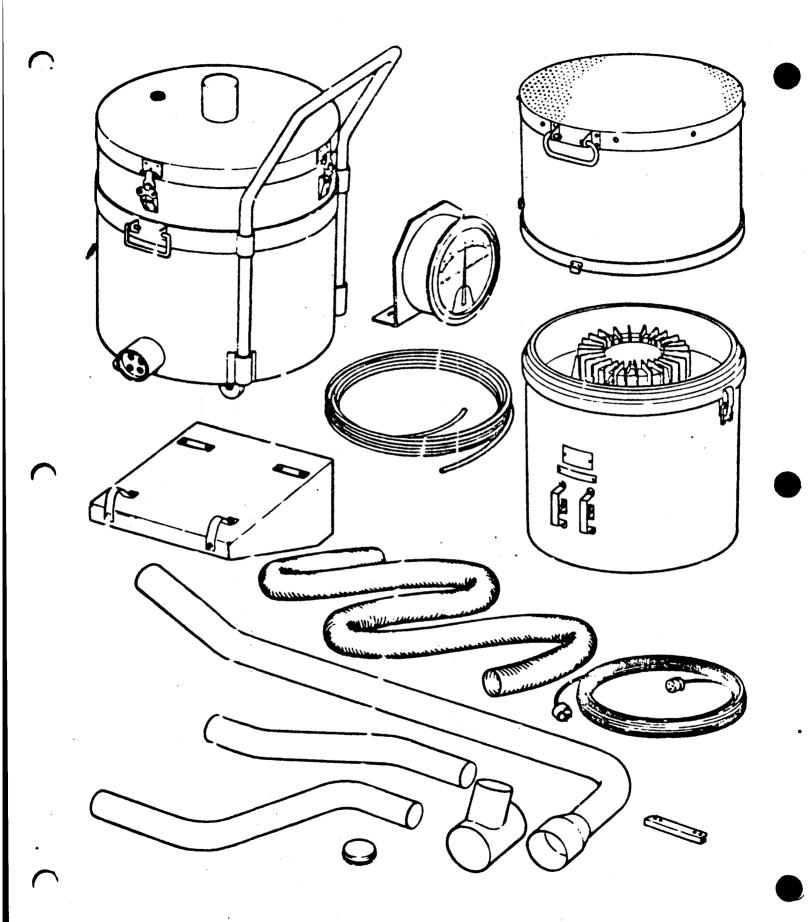


COMPTCID	<b>はつて</b> のみ	CDMTAN
CONFIGUR.	WI.TON	OPTION

	. •		
unctional requirement(s	)): 	•	
etermines weight and cen	ter of gravity on stage an	d tilt table.	
	·		
<u> </u>			
EQUIPMENT DESCRIPTION:			
Similar to DSV-7-321 inc	ludes electronics from DSV	-4B-345.	
COST \$	5,000 (DESIGN AN	D DEVELOPMENT)	•
\$\$ \$	5,000 (DESIGN AN		•
\$			•
\$ EQUIPMENT CATEGORY:	75,000 (RECURRING	/UNIT)	•
\$EQUIPMENT CATEGORY:	75,000 (RECURRING	/UNIT) AS IS 90%	•
\$ EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D	75,000 (RECURRING	/UNIT) AS IS 90%	•
\$	75,000 (RECURRING	/UNIT) AS IS 90%	•
\$ EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D	75,000 (RECURRING	/UNIT) AS IS 90%	•
\$ EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK	75,000 (RECURRING  MODIFIED 10%  NUMBER AVAILABLE  LOCATION	AS IS 90%  NUMBER	
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	75,000 (RECURRING  MODIFIED 10%  NUMBER AVAILABLE  LOCATION REQUIRED	NUMBER REQUIRED	
\$	75,000 (RECURRING  MODIFIED 10%  NUMBER AVAILABLE  LOCATION  REQUIRED  TPF/KSC	NUMBER REQUIRED	
\$	75,000 (RECURRING  MODIFIED 10%  NUMBER AVAILABLE  LOCATION  REQUIRED  TPF/KSC	NUMBER REQUIRED	
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	75,000 (RECURRING  MODIFIED 10%  NUMBER AVAILABLE  LOCATION  REQUIRED  TPF/KSC	NUMBER REQUIRED	
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	75,000 (RECURRING  MODIFIED 10%  NUMBER AVAILABLE  LOCATION  REQUIRED  TPF/KSC	NUMBER REQUIRED	

STAR TRACKER TEST SET

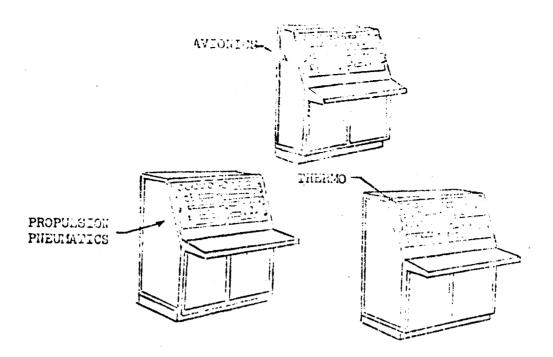
NAME: STAR TRA	CKER S	IMULATOR	EO.	UIPMENT NO. 17	4
FUNCTIONAL REQUIRE	MENT (	s):			
Simulates varying	star	magnitudes and po	sition for	Optic integrit	v during
ground checkout.					A dest still
3					
<i>*</i>					
EQUIPMENT DESCRIPT	TON.		•		
		can be attached to			
		Tan be arrached to	o the star	tracker	
	····				
					<del></del>
COST	\$	60,000 (D	ESIGN AND D	EVELOPMENT)	
	\$		recurring/u		
QUIPMENT CATEGORY:					
NEWx		MODIFIED	AS	rs	
1ST YEAR REQ'D		NUMBER AVA		10	
QUIPMENT UTILIZATI	ON:				•
FUNCTIONAL FLOW BLOCK NUMBER		LOCATION REQUIRED		NUMBER REQUIRED	
1.1.13		TPF /KSC		1	•
		PPF/WTR		1	
	<del></del>	Factory		1	
					•
-			_		
			<del>-</del>		
TAL REQUIRED	<del></del>	3	TOTAL COST		



Desiccant Kit, Static

CONFIGURATION OPTION
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NAME: STATIC DESICCA	NT KIT	EQUIPMENT NO. 175
FUNCTIONAL REQUIREMENT	(s):	
Provides contamination	control of main propel:	lant tanks when not pressurized
<i>I</i>		
EQUIPMENT DESCRIPTION:		
Breather assemblies wi	th connecting hoses and	clamps. Similar to
DSV-4B-365 & DSV-4B-45	iO kits	
	<del></del>	
	<u></u>	
		•
COST \$_	7000 (DESI	GN AND DEVELOPMENT)
\$	1000 (RECU	RRING/UNIT)
EQUIPMENT CATEGORY:		
NEW	MODIFIED ×	AS IS
1ST YEAR REQ'D		4-10-11-11-11-11-11-11-11-11-11-11-11-11-
		•
EQUIPMENT UTILIZATION: FUNCTIONAL	•	
PLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED
1.1.23	KSC	4
diameter and a second a second and a second and a second and a second and a second and a second and a second and a second and a second and a second	WTR	.2
	Factory	2
TOTAL REQUIRED	8 TOT	AL COST \$ 15.000



SUBSYSTEM MONITCRING CONSOLES

ידוגרי	TOTAL	AMTAN	ADMIAN
<b>WILL</b>	TOOU	ATION	OPTION

NAME: SUBSYSTEM MONITO	RING CONSOLES	EQUIPMENT NO. 176
FUNCTIONAL REQUIREMENT(	ស):	
	er.	of avionics subsystems and
displays status		
dishrefts status		
4		
EQUIPMENT DESCRIPTION:		
Console with intercom,	light and indicators,	, switches, and alpha numerical
display (propulsion.	avionics, thermo, pneu	matics)
· · · · · · · · · · · · · · · · · · ·	, p	
	· · · · · · · · · · · · · · · · · · ·	
		·
COST \$	70,000 (DES	SIGN AND DEVELOPMENT)
	15,000 (REC	CURRING/UNIT)
Year		
EQUIPMENT CATEGORY:		
NEW x WTR	MODIFIED	AS IS X ETR GFE
1ST YEAR REQ'D	NUMBER AVAIL	ABLE
EQUIPMENT UTILIZATION:		•
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	number Required
2.4.3	KSC	6
2.4.4	WTR	3
<del></del>		***
		<del></del>
Momat provens		DMAT COOM É 135 000
TOTAL REQUIRED	<u>9</u> T(	OTAL COST \$ 115,000

CONFIGURATION OP:	TION
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NAME: ENVIRONMENT	CONDITIONING UNIT	FQUIPMENT NO. 180	
FUNCTIONAL REQUIRES	TENT(S):	:	
Supplies condition	ed air to trapped atmosph	ere sections of the Tug	
vehicle during man	ned occupancy in those se	ections.	
EQUIPMENT DESCRIPT	ion:		
Includes blower, c	ontrols, and directed duc	ting for air flow.	
			· · · · · · · · · · · · · · · · · · ·
COST	\$ 110,000 (DE	SIGN AND DEVELOPMENT)	
	\$242,000 (RI	ECURRING/UNIT)	
EQUIPMENT CATEGORY	•		
		10 7g and	
<del></del>	<del></del>		
1ST YEAR REQ'D	NUMBER AVAI	ILABLE	
EQUIPMENT UTILIZAT	ion:	•	
Functional Flow block Number	LOCATION REQUIRED	NUMBER REQUIRED	
1.1.5	TPF/KSC	1	
	PPF/KSC	1	
****	PPF/WTR	1	
***	Factory	1	
TOTAL REQUIRED	<u>4</u> .	TOTAL COST \$ 1.078.000	

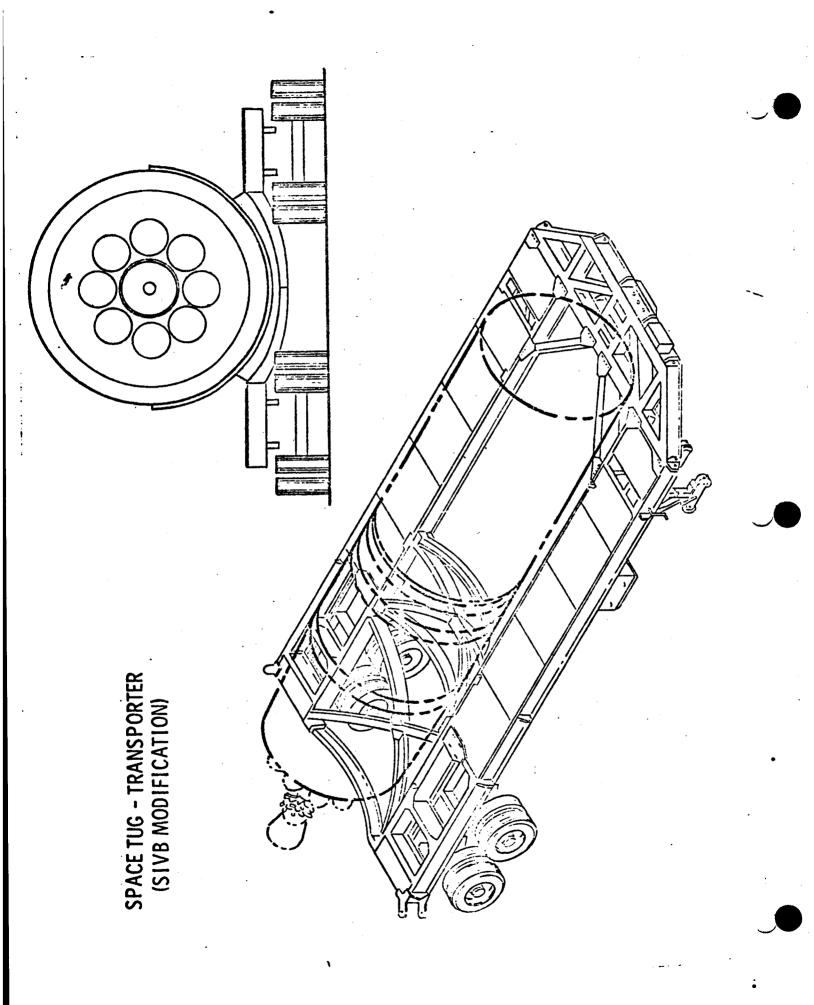
TILT TABLE HANDLING KIT

CONFIGURATION	OPTION
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MANE: IIII IABLE NA	NDLING KIT	EQUIPMENT NO. 181
FUNCTIONAL REQUIREMEN	NT(S):	
Provides means of tra	nsporting and handling	stage aft interstage.
	·	
<u> </u>		
EQUIPMENT DESCRIPTION		
Similar to DSV-4B-307	,	
Cost		SIGN AND DEVELOPMENT)
•	\$ 10,000 (RE	CURRING/UNIT)
EQUIPMENT CATEGORY:		
NEWX	MODIFIED	AS IS
1ST YEAR REQ'D_	NUMBER AVAI	LABLE
EQUIPMENT UTILIZATION	n:	•
Functional	LOCATION	NUMBER
FLOW BLOCK NUMBER	REQUIRED	REQUIRED
	REQUIRED TPF/KSC	
NUMBER		REQUIRED
NUMBER 1.1.16	- TPF/KSC	REQUIRED 2
NUMBER 1.1.16	PPF/WTR	REQUIRED 2
NUMBER 1.1.16	PPF/WTR	REQUIRED 2
NUMBER 1.1.16	PPF/WTR	REQUIRED 2

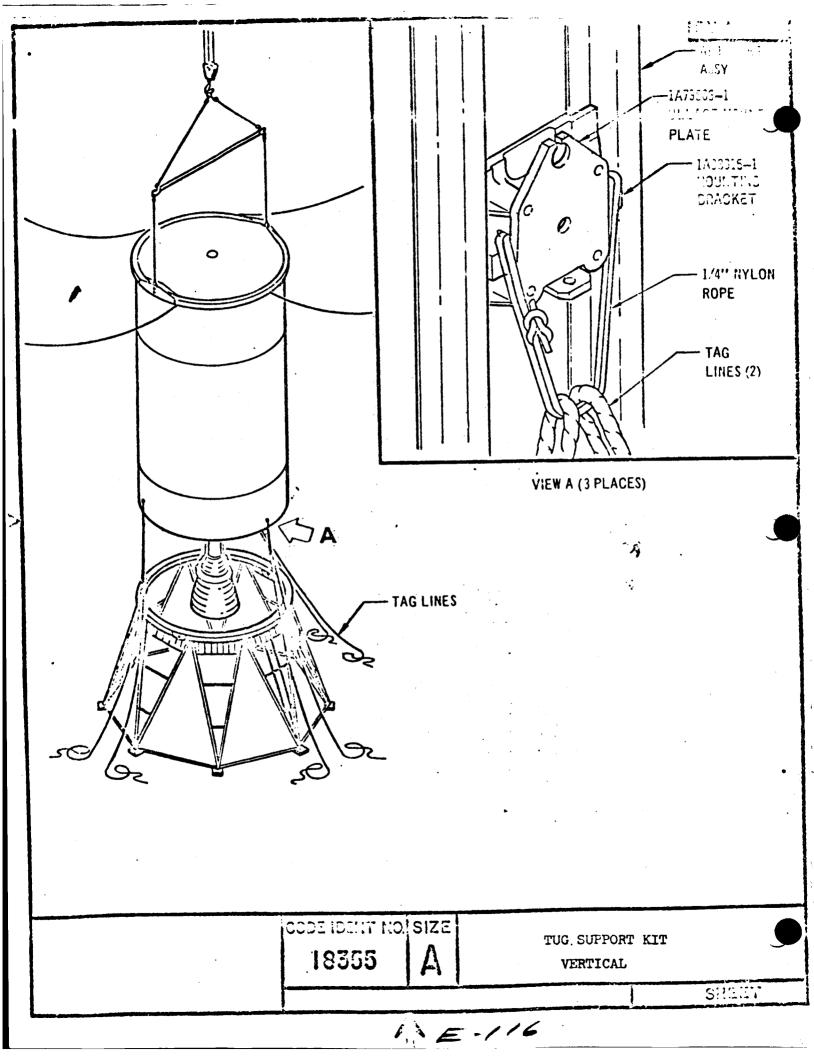
CONFIGUR	ATION	OPTION
TO	V4 7 A 11	OPILON

	TRACTOR - TR						
<b>ው፤ የአረ</b> ጥፕ /	ONAL REQUIREM	enale J.		<i>,</i>			
•	11 transporte		SC			•	
10 pu	II Cransporce	1 101 146/		· 	<del></del>	<del></del>	
<del></del>						<del></del>	
<u></u>		······································					
EQUIPM	ENT DESCRIPTION	on:					
Three	axle tractor	with sto.	5th wheel -	Ford C-80	O or equiv.		
					<del></del>	<del> </del>	
	· 	<del></del>				· · · · · · · · · · · · · · · · · · ·	<del></del>
<del></del>	<u> </u>	<u></u>		· · · · · · · · · · · · · · · · · · ·		<del></del>	<del></del>
<del></del>					<del></del>		
			(D	ESIGN AND	DEVELOPMEN	T)	
Cost		\$ 0	\D.				
Cort		· · · · · · · · · · · · · · · · · · ·			mit)		
	THE GARLOODY.	· · · · · · · · · · · · · · · · · · ·	(R		MIT)		
EQUIPM	ENT CATEGORY:	\$ 0	(R	ecurring/t		OWI - A - C	
EQUIPM	ENT CATEGORY:	\$ 0		ecurring/t	mit)	GFE at fac	ility
EQUIPM1		\$ 0 MOD	(R	ecurring/t	rs <u>x</u>	_	ility
EQUIPMI 1	NEW	\$ 0 MOD	(R	ecurring/t	rs <u>x</u>	_	ility
EQUIPMI 1	YEAR REQ'D	\$ 0 MOD	(R	ecurring/t	rs <u>x</u>	<del></del>	ility
EQUIPMI 1	YEAR REQ'D_ ENT UTILIZATIONAL FUNCTIONAL FLOW BLOCK	\$ 0 MOD	(R IFIED NUMBER AVAI LOCATION	ecurring/t	IS X  NUMBER	<del></del>	ility
EQUIPMI 1	YEAR REQ'D_ ENT UTILIZATION FUNCTIONAL FLOW BLOCK NUMBER	\$ 0 MOD	IFIED NUMBER AVAI	ecurring/t	IS X  NUMBER REQUIRE	<del></del>	ility
EQUIPMI 1	YEAR REQ'D ENT UTILIZATIONAL FLOW BLOCK NUMBER 1.1.2.1	\$ 0 MOD	IFIED  NUMBER AVAI  LOCATION  REQUIRED  KSC	ecurring/t	NUMBER REQUIRE	<del></del>	ility
EQUIPMI 1	YEAR REQ'D_ ENT UTILIZATIONAL FLOW BLOCK NUMBER 1.1.2.1 1.1.25 2.1.4	\$ 0 MOD	IFIED  NUMBER AVAI  LOCATION  REQUIRED  KSC	ecurring/t	NUMBER REQUIRE	<del></del>	ility
EQUIPMI 1	YEAR REQ'D_ ENT UTILIZATIONAL FLOW BLOCK HUMBER 1.1.2.1 1.1.25 2.1.4 2.4.5	\$ 0 MOD	IFIED  NUMBER AVAI  LOCATION  REQUIRED  KSC	ecurring/t	NUMBER REQUIRE	<del></del>	ility
EQUIPMI 1	YEAR REQ'D_ ENT UTILIZATIONAL FLOW BLOCK NUMBER 1.1.2.1 1.1.25 2.1.4	\$ 0 MOD	IFIED  NUMBER AVAI  LOCATION  REQUIRED  KSC	ecurring/t	NUMBER REQUIRES	<del></del>	ility



F-114

NAME:	Transporter		EQUIPMENT NO. 183	
FUNCTIO	ONAL RECUIREMENT (S	s):		
1	To give horizontal	support and provide mobi	lity to the	
	environmentally pr	otected Tug with a second	lary capability for	
•	roll and access.			
EQUIPM	ENT DESCRIPTION:			
-		sporter modified to incom	rporate Saturn	
<del></del>		ear and for provision of		
	cradles.			
	ER UNIT: \$\$ENT CATEGORY:	25,000 (FECUR	RING/UNIT)	
1	NEW	MODIFIED 20%	AS IS80%	
1ST	YEAR REQ'D_	NUMBER AVAILABLE	·	
EQUIPM	ENT UTILIZATION:		• Park	
	functional flow block number	LOCATION REQUIRED	NUMBER REQUIRED	
	1.1.4	KSC	3	
	1.1.2.1	WTR	2	
	1.1.2.2	Factory	1	
	1.1.25			
	2.1.4			
	2.3.4, 2.4.5			
	2.4.8			
TOTAL :	REQUIRED5	TOTAL	COST \$ 135,000	



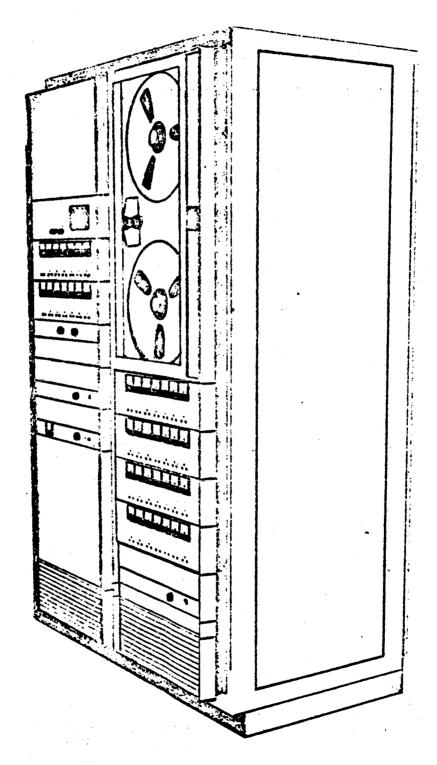
A welded struct	ural steel stand to match Tug/Si	huttle attach points and
support Tug in	a vertical position for SC matin	ng.
•		
EQUIPMENT DESCRIP	PTION:	
Welded structur	al steel tube ~4,000 lbs.	
		AND DESCRIPTION
Cort	\$ 10,000 (DESIGN	•
	\$ 80,000 (RECURR	ING/UNIT)
	**************************************	
<b>EQ</b> UIPMENT CATEGOR	-	
EQUIPMENT CATEGOR	RY:	
	RY:	AS IS
NEW	RY:  MODIFIED  NUMBER AVAILABLE	AS IS
NEW	MODIFIED NUMBER AVAILABLE ATION:	AS IS
NEW	MODIFIEDNUMBER AVAILABLE ATION: AL LOCATION CK REQUIRED	AS IS
NEW	MODIFIEDNUMBER AVAILABLE ATION: AL LOCATION CK REQUIRED LOCATION	AS IS
NEW	MODIFIEDNUMBER AVAILABLE ATION: AL LOCATION CK REQUIRED LOCATION	AS IS
NEW	MODIFIEDNUMBER AVAILABLE ATION: AL LOCATION CK REQUIRED  L KSC WTR	AS IS
NEW	MODIFIEDNUMBER AVAILABLE ATION: AL LOCATION CK REQUIRED  L KSC WTR	AS IS

UMBILICAL SYSTEM

used for post flight saf	ring.  ring.  ground-half distance 400,000	chicle or to orbiter umbilical. Also sconnects (if different from orbiter- (DESIGN AND DEVELOPMENT) (RECURRING/UNIT)
Connect test and checkou used for post flight saf  EQUIPMENT DESCRIPTION:  Orbiter-half disconnects half), and hoses.  COST  \$	it equipment to vering.	sconnects (if different from orbiter-  (DESIGN AND DEVELOPMENT)
equipment Description: Orbiter-half disconnects half), and hoses.  COST  \$	ing. , ground-half dis	sconnects (if different from orbiter-  (DESIGN AND DEVELOPMENT)
EQUIPMENT DESCRIPTION:  Orbiter-half disconnects half), and hoses.  COST  \$	, ground-half di	(DESIGN AND DEVELOPMENT)
Orbiter-half disconnects half), and hoses.  COST \$  EQUIPMENT CATEGORY:	400,000	(DESIGN AND DEVELOPMENT)
Orbiter-half disconnects half), and hoses.  CONT \$  EQUIPMENT CATEGORY:	400,000	(DESIGN AND DEVELOPMENT)
Orbiter-half disconnects half), and hoses.  COST \$  EQUIPMENT CATEGORY:	400,000	(DESIGN AND DEVELOPMENT)
Orbiter-half disconnects half), and hoses.  CONT \$  EQUIPMENT CATEGORY:	400,000	(DESIGN AND DEVELOPMENT)
half), and hoses.  COST \$  EQUIPMENT CATEGORY:	400,000	(DESIGN AND DEVELOPMENT)
COST \$ \$ EQUIPMENT CATEGORY:	400,000	(DESIGN AND DEVELOPMENT)
EQUIPMENT CATEGORY:		
	50,000	(RECURRING/UNIT)
NEW Y		
· · · · · · · · · · · · · · · · · · ·	MODIFIED_	AS IS
1ST YEAR REQ'D	NUMBER AV	/AILABLE
EQUIPMENT UTILIZATION:		
FUNCTIONAL	- AGAMTOW	MIRADED
Plow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
1.1.5	KSC (Launch	pad) 2
2.3.2.2	TPF/KSC	1
2.3.9	MCF/KSC	1
2.4.2	Factory	1
2.4.5	PPF/WIR	1
	MCF/WTR	1

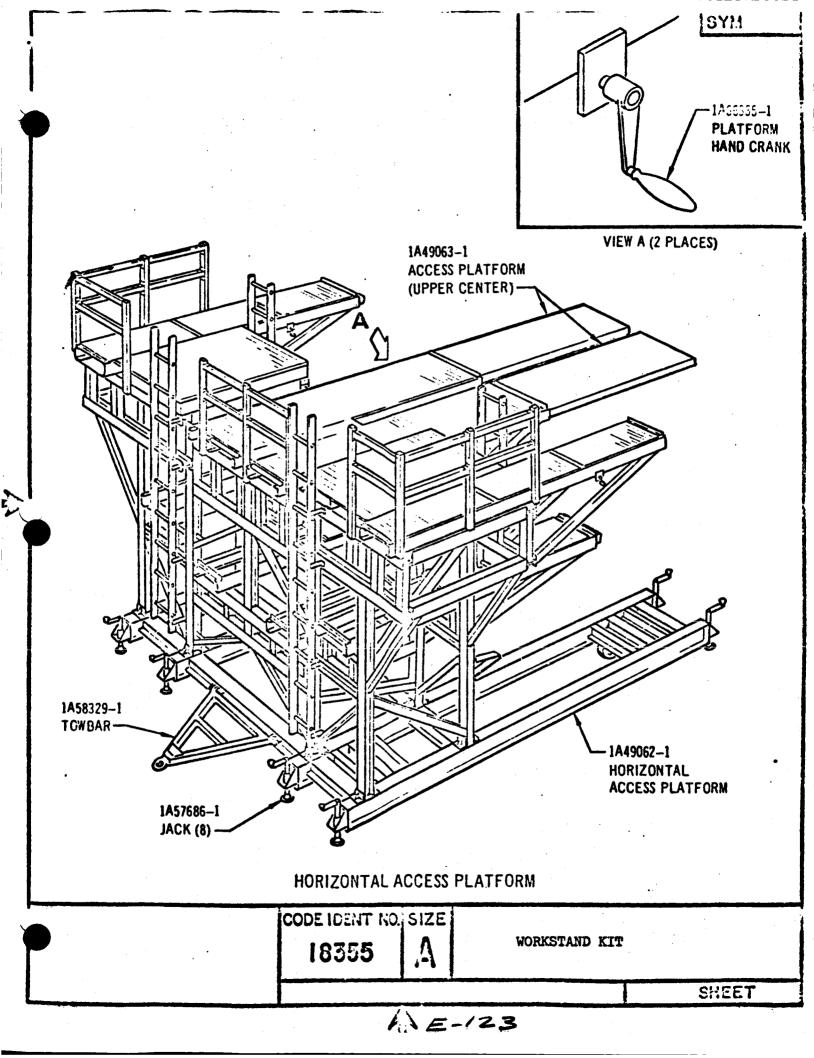
CONFIGURATION	OPTION	

NAME: VOICE AND TIMING	SYSTEM	EQUIPMENT NO. 189	
functional requirement (	s):	•	
Records timing and voice	on Wide Band Magnetic Tap	e Recorder.	
7			
DOCUMENT DOCUMENTON			· · · · · · · · · · · · · · · · · · ·
EQUIPMENT DESCRIPTION:	·		
Similar to DSV-4B-772		•	
		•	<u> </u>
cost \$_	10.000 (DESIGN	AND DEVELOPMENT)	
\$_	6.000 (RECURRI	ING/UNIT)	
EQUIPMENT CATEGORY:			
NEW	MODIFIED	AS IS 100%	
<del></del>	NUMBER AVAILABLE		
EQUIPMENT UTILIZATION:			
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
2.4.3	KSC (BLOCKHOUSE)	1 GFE at	ETR
	WTR (BLOCKHOUSE)	1	
<del></del>			
TOTAL REQUIRED	2	L COST \$ 16,000	



WIDE DAND INGREED TAPL RECORDER

MINIO MILLION DANS	I MAGNETLE TA	PE RECORDER	EQUIPMENT NO. 190
		PE RECORDER	
ICTIONAL REQUI	REMENT(S):		
Receives and s	stores TM dat	a for eventual playb	ack and data analysis.
	<del></del>		
	. ·		
QUIPMENT DESCRI	IPTION:		
Similar to DS	V-4B-127		
			•
ОСТ	\$	12,000 (DESIG	N AND DEVELOPMENT)
	\$	47,000 (RECUR	RING/UNIT)
OUTPMENT CATEG	CORY:		
		MODIFIED	
NEW X	WTR 1	MODIFIEDAVAILAR	AS IS X ETR
NEW_X	WTR 1		
NEW X  1ST YEAR REQUERNENT UTILE	WTR !		AS IS X ETR
NEW X  1ST YEAR REQUIPMENT UTILITY  FUNCTION FLOW BI	WTR I		AS IS X ETR
NEW X  1ST YEAR REQUIPMENT UTILLY FUNCTION FLOW BITTON BETT	WTR I	NUMBER AVAILABI	AS IS X ETR  LE NUMBER
NEW X  1ST YEAR REQUIPMENT UTILITY  FUNCTION FLOW BITTON NUMBER  1.1.7	WTR I	NUMBER AVAILAB	AS IS X ETR  LE  NUMBER  REQUIRED
NEW X  1ST YEAR REQUIPMENT UTILLY FUNCTION FLOW BITTON BETT	WTR I	NUMBER AVAILABING LOCATION REQUIRED	AS IS X ETR  NUMBER REQUIRED  1 GFE ETR
NEW X  1ST YEAR REQUIPMENT UTILITY  FUNCTION FLOW BITTON NUMBER  1.1.7	WTR I	NUMBER AVAILABI	AS IS X ETR  LE  NUMBER  REQUIRED
NEW X  1ST YEAR REQUIPMENT UTILITY  FUNCTION BIT NUMBER  1.1.7	WTR I	NUMBER AVAILABING LOCATION REQUIRED	AS IS X ETR  NUMBER REQUIRED  1 GFE ETR
NEW X  1ST YEAR REQUIPMENT UTILITY  FUNCTION BY NUMBER  1.1.7	WTR I	NUMBER AVAILABI LOCATION REQUIRED TPF/KSC MCF/KSC	AS IS X ETR  NUMBER REQUIRED  1 GFE ETR  1 GFE ETR
IST YEAR REQUEST UTILITY FUNCTION FLOW BITTH NUMBER 1.1.7	WTR I	LOCATION REQUIRED TPF/KSC MCF/KSC PPF/WTR	AS IS X ETR  NUMBER REQUIRED  1 GFE ETR  1 GFE ETR



CONFIGURATION	OPTION	411
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IAME: WURASTAND - RIT	· · · · · · · · · · · · · · · · · · ·	UIPMENT NO. 191
	•	
UNCTIONAL REQUIREMENT(S		eth while installed on
To provide access to si	de and end of Tug (space cra	art) while installed on
transporter.		
<i>*</i>		
QUIPMENT DESCRIPTION:		
-	teel angle and grating plats	form meted to transporter.
	•	
End access steel ang	le and grating structure wi	th extensible platforms, mat
to transporter.		
	•	
COST \$	15,000 (DESIGN AND	D DEVELOPMENT)
\$	12.000 (RECURRING	/unit)
EQUIPMENT CATEGORY:		
-	MODIFIED A	AS IS
1ST YEAR REQ'D_	NUMBER AVAILABLE	U
EQUIPMENT UTILIZATION:		
FUNCTIONAL	LOCATION	NUMBER
•	LOCATION REQUIRED	•
FUNCTIONAL FLOW BLOCK		NUMBER
FUNCTIONAL FLOW BLOCK NUMBER	REQUIRED	NUMBER REQUIRED
FUNCTIONAL FLOW BLOCK NUMBER 1.1.5	REQUIRED PPF/KSC	NUMBER REQUIRED
FUNCTIONAL FLOW BLOCK NUMBER  1.1.5  2.2.1.1	PPF/KSC  Storable Prop/KSC	NUMBER REQUIRED  2
FUNCTIONAL FLOW BLOCK NUMBER  1.1.5  2.2.1.1  2.2.2	PPF/KSC  Storable Prop/KSC  TPF/KSC	NUMBER REQUIRED  2
FLOW BLOCK NUMBER  1.1.5  2.2.1.1  2.2.2  2.3.2.2	PPF/KSC  Storable Prop/KSC  TPF/KSC  PPF/WTR	NUMBER REQUIRED  2  1  3

NAME: SECURITY VE	11CLE	EQUIPMENT NO	
FUNCTIONAL REQUIRES	MENT(S):		
Provide on-site to	ransportation for the securi	ity personnel accompanio	ng
	d secure Tug vehcle from cla		
	1 secure rux vencre from cra	issified facility to cia	13311100
facility			<u> </u>
			<del> </del>
EQUIPMENT DESCRIPT	ON:		
Two axle motoriz	ed vehicle GFE at facility	•	
			٠.
	·		· · · · · · · · · · · · · · · · · · ·
		·	
-			
COST	\$ -0- (DESI	GN AND DEVELOPMENT)	
		JRRING/UNIT)	
		MILIO, ORII,	
EQUIPMENT CATEGORY:	<b>:</b>		
NEM X	MODIFIED	AS IS	
1ST YEAR REQ'D_	NUMBER AVAILA	BLE	
EQUIPMENT UTILIZAT	ION:	•	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
2.2.1.1	. KSC	3	
2.3.1	WTR	. 3	.*
2.3.4			
2.4.8			
<del></del>			
TOTAL REQUIRED	6 <b>TO</b>	TAL COST \$0-	

CONFIGURATION	OPTION
---------------	--------

NAME: SIMULATION FLIGHT	TEST COMPUTER PROGRAM	EQUIPMENT NO.	301
functional requirement (s	):		
Simulated flight test (	integrated system test	t) verifies Orbiter an	nd Tug operate
as a system. Verifies	all interfaces in a s	imualted flight mode a	approximate 40K
			مستناك بماريكا وسيدين وسيدين
EQUIPMENT DESCRIPTION:			
Magnetic tape or disk.	listing and test proc	edure.	
		•	
**************************************			
COST PER UNIT: \$_1			
\$ <u></u>	584,225 (RECU	RRING)	
EQUIPMENT CATEGORY:			
NEW	MODIFIED	AS IS	
1ST YEAR REQ'D	NUMBER AVAILA	BLE	
EQUIPMENT UTILIZATION:		•	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
2.3.9	MCF KSC	1	<del>,,,,</del>
2.4.1	MCF WTR	<u> </u>	<del></del>
2.4.3	Factory	1	··-
William Andrew Court, and an in the court of			<del></del>
	-		
TOTAL REQUIRED 3	T(	OTAL COST \$ 1,914,00	5

NAME: GROUND CHECK	COUT COMPUTER PROGRAMS	EQUIPMENT NO. 302
FUNCTIONAL REQUIREM	ent(s):	
		and ground checkout computer.
	r, Executive and ground che	
<i>t</i>		
EQUIPMENT DESCRIPTI	ON:	
Magnetic tape of d	isk; listing, and test proc	edure. 28K approximate memory
instructions. (GS	E computer checkout execut	ive program 20K, flight computer checko
executive 8K.)		
0.00	e 290.640 (DES	IGN AND DEVILOPMENT)
COST	\$ 29,064 (REC	
	**************************************	,
EQUIPMENT CATEGORY		AS IS
NEWX	<del></del>	
1ST YEAR REQ'D	NUMBER AVAIL	ABLE
EQUIPMENT UTILIZAT	ION:	
Functional Flow Block Number	IACALLON	NUMBER REQUIRED
2.3.9	KSC	1
2.4.1	WTR	<u> </u>
2.4.3	Factory	1
		And the second s
<del></del>		
·		
		omes oces & 210 70h
TOTAL REQUIRED		OTAL COST \$ 319,704

CONFIGURATION	OPTION	
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NAME: GROUND CHECK	COUT TUG PROCESSING FACILI	TY EQUIPMENT NO. 304	
COMPUTER PRO	GRAMS		
FUNCTIONAL REQUIRE	ment(s):		
Instrumentation sy	stem calibration & test.	All system test. Subsystems	test
(used on long stor	rage Tugs) Programs for po	wer distribution test, commun	ication
test, ACPS, engine	e gimballing (steering), p	propulsion - pressurization, p	ropellant
Utilization, engin	ne electronics, thermal co	entrol, data management, and g	uidance
Navigation & Contr EQUIPMENT DESCRIPT	'ION:		
Magnetic tape or d	disk, listing, and test pr	cocedure. 256K approximate me	mory
instructions. (Tu	g power on/off 10K, power	distribution 25K, communicat	ions 20K,
propellant utiliz	ation 6K, APCS 20K, engine	e gimballing 20K, propulsion	40K, data
managment 20K, GN	&C 15K, instrumentation sy	ystem test and control 35K, a	ll system
test 45K.			
COST	\$ 2,657,280 (D	ESIGN AND DEVELOPMENT)	
	\$	ECURRING)	
EQUIPMENT CATEGORY	(:		
NEWx	MODIFIED	AS IS	
1ST YEAR REQ'D_	NUMBER AVA	CLABLE	
EQUIPMENT UTILIZAT	PION:	•	
FUNCTIONAL FLOW BLOCK NUMBER	LACATION	NUMBER REQUIRED	
1.1.8.9	KSC	1	
	WTR	1	
	Factory	1	
		<del></del> ,	
TOTAL REQUIRED	3	TOTAL COST \$ 3,006.605	-

CONFIGURATION	OPTION	
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FUNCTIONAL RECUIREMENT(S):  GSE Integrity checks and sel  POULPMENT DESCRIPTION:  Magnetic tape or disk, listin instructions. (GSE/Tug connections.)	ng, and test pro	ocedure. 65		
EQUIPMENT DESCRIPTION:  Magnetic tape or disk, listing instructions. (GSE/Tug connections)	ng, and test pro	ocedure. 65		
Magnetic tape or disk, listin instructions. (GSE/Tug connections)				
Magnetic tape or disk, listin instructions. (GSE/Tug connections)				
Magnetic tape or disk, listin instructions. (GSE/Tug connections)				
Magnetic tape or disk, listin instructions. (GSE/Tug connections)				
instructions. (GSE/Tug connec				
_		2		
70K. 7		<u></u>		
COST \$ 67	4.700 (DE	SIGN AND DEV	relopment)	
\$6	7.470 (RE	CURRING)		
EQUIPMENT CATEGORY:	•	•		
NEWX MOD	IFIED	_ AS IS	<del></del>	
1ST YEAR REQ'D	_ NUMBER AVAIL	LABLE		
EQUIPMENT UTILIZATION:		•	•	
Functional Flow Block Number	LOCATION REQUIRED		NUMBER REQUIRED	
1.1.5	KSC		1	
2.3.9	WTR	· ·	1	
	Factory		1	
· ·		,		
		_		
			742,170	

NAME: LAUNCH COURT	TDOWN	COMPUTER PROGRA	MS EQUIPMENT NO. 306
FUNCTIONAL REQUIRES	ÆNT (S	3):	
Simulated flight t	est p	rogram, propella	nt loading, and countdown program
	(p	ower transfer, v	ehicle status and redline checks)
	,		
EQUIPMENT DESCRIPT	ION:		
		listing test pro	cedure, countdown manuals. 65K
approximate memory	instr	uctions. (Propel	lant loading program 35K; countdown program
3oк.)		. **	
COST	\$	674,700	(DESIGN AND DEVFLOPMENT)
	\$	67,470	(RECURRING)
EQUIPMENT CATEGORY	:		
newx		MODIFIED	AS IS
1ST YEAR REQ'D		NUMBER	AVAILABLE
EQUIPMENT UTILIZAT	ION:	•	
Functional Flow block Number		LOCATIO REQUIRE	
2.4.3		. KSC	1
		WTR	1.
mom. I provide	<del></del>	2	
TOTAL REQUIRED		2	TOTAL COST \$ 742,170

CUNFIGURATION	OPTION	

NAME: SUPPORT SOFTWA	RE COMPUTER PROGRAMS	EQUIPMENT NO. 307
FUNCTIONAL REQUIREMENT		a state and enlibration
		on dictionary and calibration
program, system sim	nulation program, Tug flight	computer emulator, orbiter/Tug
checkout computer e	mulator, Fortran equation m	model program, trend data analysis
program, flight pro	gram assembler and orbiter/	Tug computer program assembler
EQUIPMENT DESCRIPTION		· · · · · · · · · · · · · · · · · · ·
		edure. 80K approximate memory
المتالة المتناك فالمستوان والبائدية والمتناوع والمتناوع والمتناوع والمتناوع والمتناوع والمتناوع والمتناوع والمتناوع		dictionary program 10K, compiler/
assembler program		
Section of the contract of the		
COST	\$ 830,400 (DESIG	N AND DEVELOPMENT)
	\$ 83,040 (RECUE	RRING)
EQUIPMENT CATEGORY:		
NEWx	MODIFIED	AS IS
1ST YEAR REQ'D_	NUMBER AVAILAB	LE
EQUIPMENT UTILIZATION	ON:	•
FUNCTIONAL	LOCATION	NUMBER
FLOW BLOCK NUMBER	REQUIRED	REQUIRED
2.3.9	KSC	1
2.4.1	· WTR	1
2.4.3	Factory	1
<del></del>		
<del></del>		
TOTAL REQUIRED	3	ral cost \$ 913,400
	•	

CONFIGURATION	OPTION	01	
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WBS 32A-07-01

KAME: AEDC INTERFA	CE CAB	LE KIT		EQUIPMENT NO	308
UNCTIONAL REQUIR					
Instrumentation re	equired	to instrument	t Tug for	propulsion test ve	chicle testing
in J4 test cell a					
EQUIPMENT DESCRIP	TION:			•	
50 Instrumentatio	n cable	es run between	Tug and j	unction box. Also	o, 6 interface
cables.		,	·		
	<del></del>				
· · · · · · · · · · · · · · · · · · ·	<del></del>	· · · · · · · · · · · · · · · · · · ·			
COST PER UNIT:	\$	13,500			
	\$	30,000	(RECUR	RING/YEAR)	
EQUIPMENT CATEGOR	RY:				
NEW_X	<del></del>	MODIFIED_		AS IS	
				LE	
EQUIPMENT UTILIZA	ATION:				
FUNCTIONA FLOW BLOO NUMBER	AL	LOCA REQU	TION	NUMBER REQUIRED	
		_			
		-			
-		·	<u> </u>		
<del></del>		_			
		_		-	
		•	- · · <del>-</del>		
TOTAL REQUIRED _	· · · · · · · · · · · · · · · · · · ·		TO	ral cost \$ 43,500	

E-132

# PTV GSE DECCHIPTION SHEET

## WBS 32A-07-01

IAME • TUG TEST CE	LL HOLDING FIXTURE	EQUIPMENT NO. 309
UNCTIONAL REQUIREM		
iolding fixture to	mount Tug in the J4 test ce	ell at AEDC.
EQUIPMENT DESCRIPTI	ON:	
	ing fixture that adapt to T	ing and test cell.
COST FER UNIT:	\$ 8,750 (NON-	-RECURRING)
	\$ 6,000 (REC	urring/year)
EQUIPMENT CATEGORY	· :	
NEW		AS IS
	NUMBER AVAIL	
EQUIPMENT UTILIZAT		•
FUNCTIONAL		NUMBER
FLOW BLOCK NUMBER	<b>DOO!!</b>	REQUIRED
-		
TOTAL REQUIRED		TOTAL COST \$ 14,750

WBS 32A-07-01

mctional requirement			
strumentation junctic	on box required to interfe	ace with J4 test cell	at AEDC.
			·
QUIPMENT DESCRIPTION:			
unction box with 500	twisted shielded wire and	60 connectors.	· · · · · · · · · · · · · · · · · · ·
			· · · · · · · · · · · · · · · · · · ·
COST PER UNIT: \$_			
<u>.</u>	16,000 (RECUR	ring/year)	
equipment category:			
NEW	MODIFIED	AS IS	•
1ST YEAR REQ'D	NUMBER AVAILAB	LE	
EQUIPMENT UTILIZATION			
FUNCTIONAL	LOCATION	NUMBER	
Flow block Number	REQUIRED	REQUIRED	
	REQUIRED	REQUIRED	•
	REQUIRED	REQUIRED	
· · · · · · · · · · · · · · · · · · ·	REQUIRED	REQUIRED	•

## WBS 32A-07-01

NAME: TEST SOFTWARE COMP	PUTER PROGRAMS	EQUIPMENT NO. 311
UNCTIONAL REQUIREMENT(S		
Test software to control	the propulsion test veh	icle testing in J4 test cel:
at AEDC.		
·		
EQUIPMENT DESCRIPTION:		
	listing and test procedu	ure. (See attachment.)
		•
	20,760 (NON-RE	
\$	-0- (RECURR	ING/YEAR)
EQUIPMENT CATEGORY:		
NEW X	MODIFIED	AS IS
	NUMBER AVAILABL	
EQUIPMENT UTILIZATION: FUNCTIONAL	- 004 MTOY	NUMBER
FLOW BLOCK NUMBER	LOCATION REQUIRED	REQUIRED
	AEDC J4 Test Cell	1
	_	
· · · · · · · · · · · · · · · · · · ·		
	-	
TOTAL REQUIRED	rot	AL COST \$ 20,760

## TEST SOFTWARE REQUIREMENTS (AEDC) J4 TEST CELL

- A. Define instrumentation requirements
  - 1. Assign data channels and speeds for analog data.
  - 2. Assign discrete-channels.
  - 3. Determine data recording requirements (tape recording, strip chart, and real time reduction via Raytheon 520 and IBM 360/50 computers).
- ♠ 4. Determine console real time data display requirements.
  - 5. Determine checkout computer (IBM 360/44 data input requirements for real time test control and monitoring).
- B. Define control parameters
  - 1. Assign control functions for manual control panels in J4 test cell.
  - 2. Assign checkout computer control functions (relay closures and logic level).
- C. Define calibration data-
  - 1. Determine calibration for facility instrumentation (use trend data from other test programs).
  - 2. Determine calibration for the test peculiar parameters.

It is assumed that AEDC J4 test cell provides channel assignments list, calibration data, signal routing requirements from existing support software programs.

MDAC will have to provide inputs to these programs through Interface Control Documents (ICD).

#### COLD FLOW TEST

Develop a checkout/control program to perform the Cold Flow Test. This program to be executed on the IRM 360/44 computer will provide the following:

- a. Automatically accomplish facility monitoring and control.
- b. Initiate, monitor, and terminate cold flow per the design parameters.
- c. Secure test article and facility.
- d. Provide the emergency shutdown sequences.

This program is sized at 12,000 words which include limited real time documentation via a line printer.

AME: MISSION CONTROL TUG	SUBSYSTEM SOFTWARE FOU	IPMENT NO. 312
unctional recuirement(s):		
rovide software to drive	displays for Tug subsystem	status. Utilizing existing
		routines for Tug peculiar
unctions.		
QUIPMENT DESCRIPTION:	magnetic tames	
Card decks, listings, and	magnetic tapes.	
	·	
COST PER UNIT: \$ 5	173,500 (NON-RECORK	ING) FOR NASA AND DOD COMBI
EQUIPMENT CATEGORY:		
NEW	MODIFIEDA	s is
ist year req'D_	NUMBER AVAILABLE	
EQUIPMENT UTILIZATION:		•
Punctional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
	NASA Mission Control	1
	DOD Mission Control	<u> </u>
	-	
The second secon		• ,

CONFIGURATION	OPTION	
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NAME: DOD MISSION C	ONTROL STATUS AND MONITORING STATIONS	EQUIPMENT NO. 313	
FUNCTIONAL REQUIREM	ent(s):		
Provide Tug status	to DOD mission control for p	roviding up/down link	commands.
	tatus for trajectory and gui		
	ement, test director, and re		
<b>&amp;</b>			
EQUIPMENT DESCRIPTI	•		
•	wn consoles with cathode ray	tube, alpha numerical	displays,
	associated circuitry.		
			<del></del>
CCC ANNOTATION OF THE PROPERTY			
COST PER UNIT:	\$ (NON-R)	ecurring)	
•	\$(RECUR!	ring/year)	
EQUIPMENT CATEGORY:			
NEW	MODIFIED	AS IS X GFE	
1ST YEAR REQ'D	NUMBER AVAILAB	LE	
EQUIPMENT UTILIZATI	ion:		
FUNCTIONAL FLOW BLOCK	LOCATION	NUMBER	
NUMBER	REQUIRED	REQUIRED	
	DOD Mission Contro	01 7	
######################################	Was .		
TOTAL REQUIRED	TOT	AL COST \$ -0-	

NAME: NASA MISSION CONTRO		EQUIPMENT NO. 314	
FUNCTIONAL REQUIREMENT(S)	STATIONS		
•		iding un/doem link o	omma nda
Provide Tug status to NAS			
Provide subsystem status	for trajectory and guide	ince; propulsion, elect:	rical powe
thermal, data management,	test director, and rend	lezvous and docking fun-	ctions.
<i>T</i>			
EQUIPMENT DESCRIPTION:			
Seven two bay sitdown con	soles with cathode ray	tubes, alpha numerical	displays,
		,	
communications, and assoc	raced circuitry.		
			<del></del>
		•	
COST PER UNIT: \$	(NOT-REC	urring)	
\$	(RECURRI	nc/year)	
EQUIPMENT CATEGORY:	•	•	
NEW	MODIFIED	AS IS X GFE	
IST TEAR REQ.D	NUMBER AVAILABLE		
EQUIPMENT UTILIZATION:			
Functional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED	•
	NASA Mission Contro	· 17	
		•	
**************************************			
***			
TOTAL REQUIRED	TOTAL	COST \$ -0-	

#### TABLE OF CONTENTS

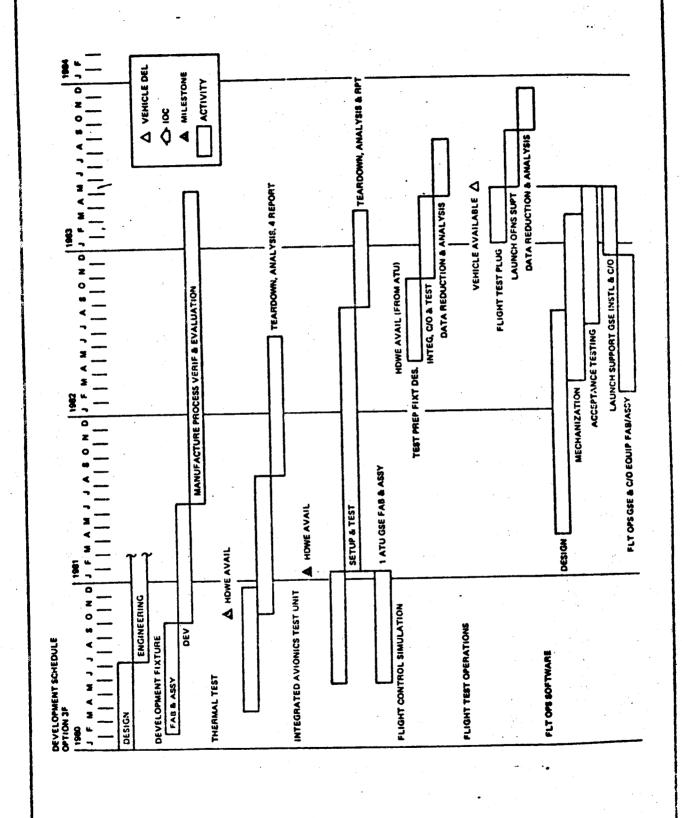
# OPTION 3F - The following GSE are a Delta to 3I GSE AND SOFTWARE DESCRIPTION

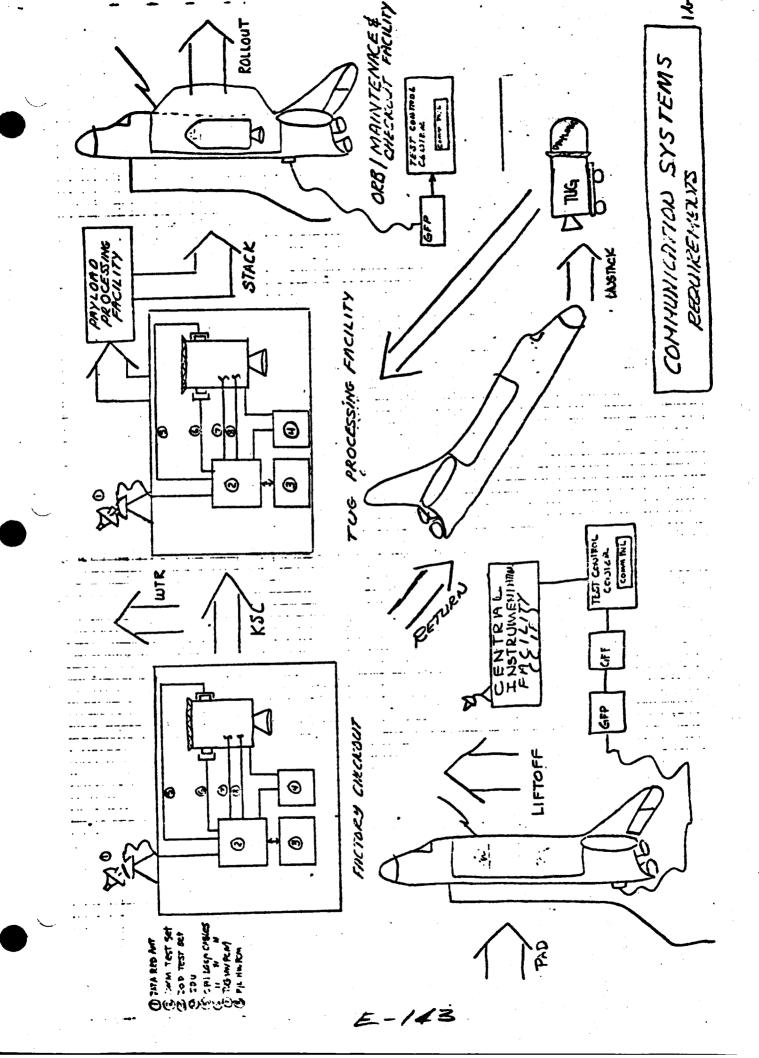
- 1a HARDWARE AND SOFTWARE DEVELOPMENT SCHEDULE
- 16 COMMUNICATION SYSTEM REQUIREMENTS
- 1c CHECKOUT AND VERIFICATION FLOW
- 1d CHECKOUT SOFTWARE DEVELOPMENT AND OPERATION TASK FLOW
- Te PLIGHT SOFTWARE DEVELOPMENT AND OPERATION TASK FLOW
- 1f FACTORY CHECKOUT BLOCK DIAGRAM
- 1g TIG PROCESSING FACILITY BLOCK DIAGRAM
- 11: ORBITER MAINTENANCE AND CHECKOUT BLOCK DIAGRAM
- LAUNCH PAD BLOCK DIAGRAM
- INTEGRATED AVIONICS TEST
- PROPULSION TEST VEHICLE/GROUND SUPPORT EQUIPMENT ASSEMBLY
- 113 APS SERVICER GSE DESCRIPTION
- 118 CHECKOUT CABLE KIT GSE DESCRIPTION
- 120 COMPONENT PROTECTIVE COVERS GSE DESCRIPTION
- 122 COVERS SPACECRAFT/TUG DRAWING
- 122 COVER SPACECRAFT GSE DESCRIPTION
- 123 COVER TUG GSE DESCRIPTION
- 124 CRADLES DRAWING
- 124 CRADLES GSE DESCRIPTION
- 125 CRYOGENIC PROPELLANT LOADING COMPLEX DRAWING
- 125 CRYOGEHIC PROPELLANT LOADING COMPLEX GSE DESCRIPTION
- 127 DATA MANAGEMENT SYSTEM T/S (DMST/S) DRAWING
- 127 DATA MANAGEMENT SYSTEM T/S (DMST/S) GSE DESCRIPTION
- 135 FM TRANSMITTER COMPONENT TEST SET DRAWING
- 135 FM TRANSMITTER COMPONENT TEST SET GSE DESCRIPTION
- 136 FREQUENCY CALIBRATION UNIT DRAWING
- 136 FREQUENCY CALIBRATION UNIT RACK ASSEMBLY GSE DESCRIPTION
- 137 FUEL CELL CHECKOUT KIT DRAWING
- 137 FUEL CELL CHECKOUT KIT DESCRIPTION
- 142 GUIDANCE AND NAVIGATION TEST SET DRAWING
- 142 GUIDANCE AND NAVIGATION TEST SET GSE DESCRIPTION
- 143 GUIDANCE AND NAVIGATION SYSTEM CHECKOUT KIT GSE DESCRIPTION
- 144 LASER RADAR CHECKOUT AND ANALYSIS KIT DRAWING
- 144 LASER RADAR CHECKOUT AND ANALYSIS KIT GSE DESCRIPTION

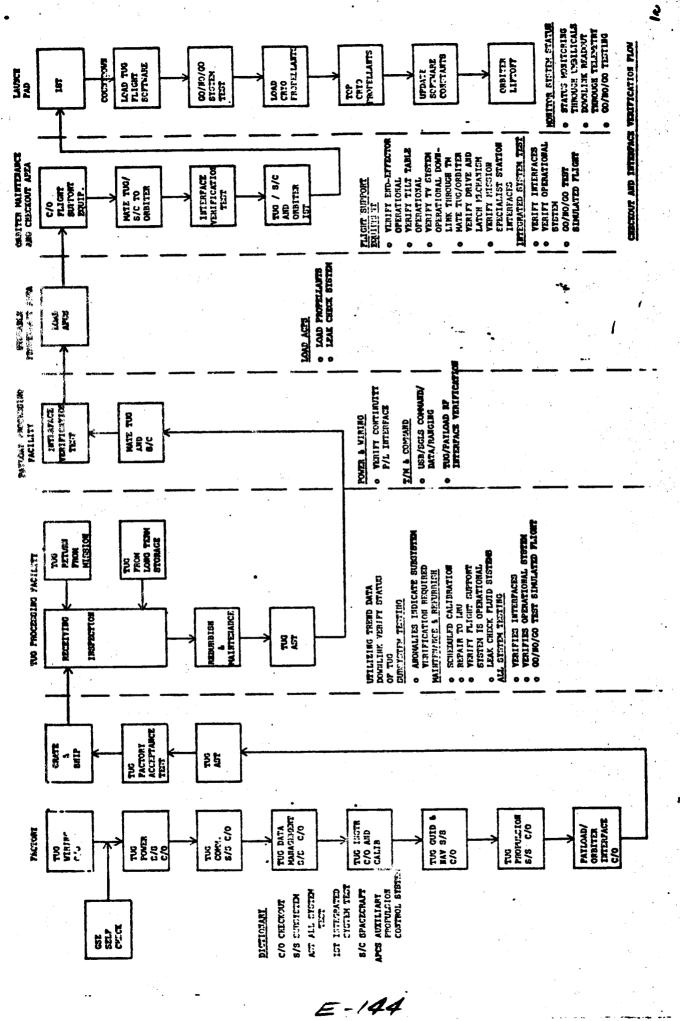
#### TABLE OF CONTENTS (CONT'd)

145	LAUNCH COUNTDOWN CONSOLE DRAWING
145	LAUNCH COUNTDOWN CONSOLE GSE DESCRIPTION
147	LH2-He HEAT EXCHANGER DRAWING
147	LH2-He HEAT EXCHANGER GSE DESCRIPTION
148	SIGNAL CONDITIONING UNIT DRAWING
148	SIGNAL CONDITIONING UNIT GSE DESCRIPTION
149	ORBITER SIMULATOR DRAWING
149	ORBITER SIMULATOR GSE DESCRIPTION
155	POWER SYSTEM T/S (PSTS) DRAWING
	POWER SYSTEM T/S (PSTS) GSE DESCRIPTION
162	PNEUMATIC SKID LAUNCH DRAWING
162	PNEUMATIC SKID LAUNCH GSE DESCRIPTION
163	PROPELLANT OR PNEUMATIC CONTROL CONSOLE DRAWING
163	PROPELLANT OR PNEUMATIC CONTROL CONSOLE GSE DESCRIPTION
168	SPACECRAFT SIMULATOR DRAWING
168	SPACECRAFT SIMULATOR GSE DESCRIPTION
169	SPACE TUG SIMULATOR DRAWING
169	SPACE TUG SIMULATOR GSE DESCRIPTION
-	STAGE WEIGH AND BALANCE KIT DRAWING
173	STAGE WEIGH AND BALANCE KIT GSE DESCRIPTION
176	SUBSYSTEM MONITORING CONSOLES DRAWING
176	SUBSYSTEM MONITORING CONSOLES GSE DESCRIPTION
183	TRANSPORTER DRAWING
183	TRNASPORTER GSE DESCRIPTION
- 0-	TOTAL OVERTIME DEALTIME

- 185 UMBILICAL SYSTEM DRAWING
- 185 UMBILICAL SYSTEM GSE DESCRIPTION
- 189 VOICE AND TIMING SYSTEM GSE DESCRIPTION
- 301 SIMULATION FLIGHT TEST COMPUTER PROGRAM GSE DESCRIPTION
- 304 GROUND CHECKOUT TUG PROCESSING FACILITY COMPUTER PROGRAMS GSE DESCRIPTION
- 311 TEST SOFTWARE COMPUTER PROGRAMS DESCRIPTION







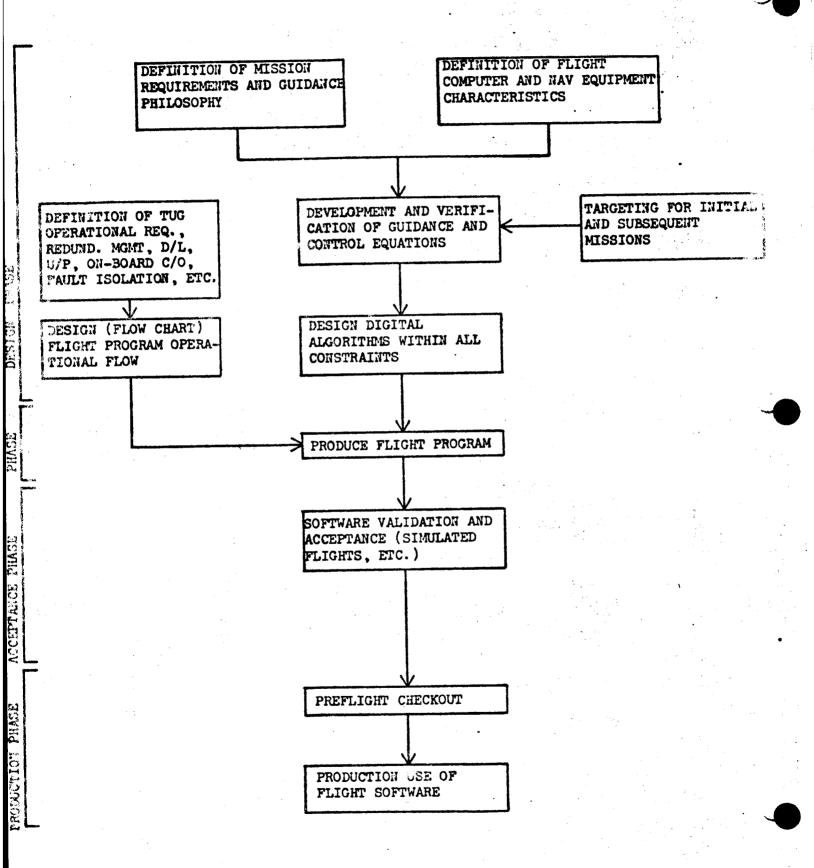
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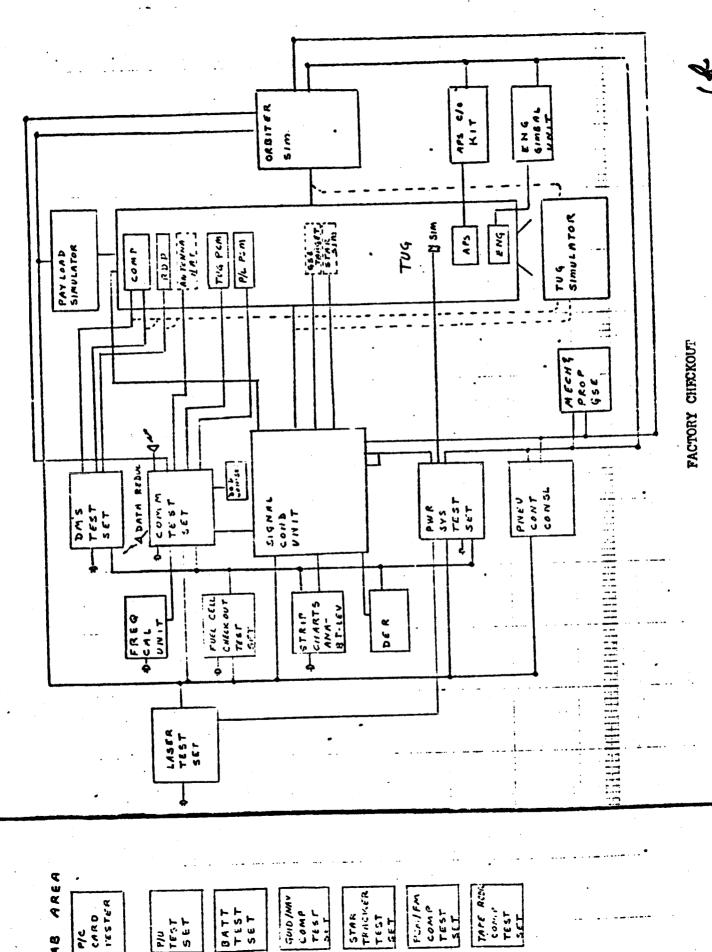
E STATE OF THE STA

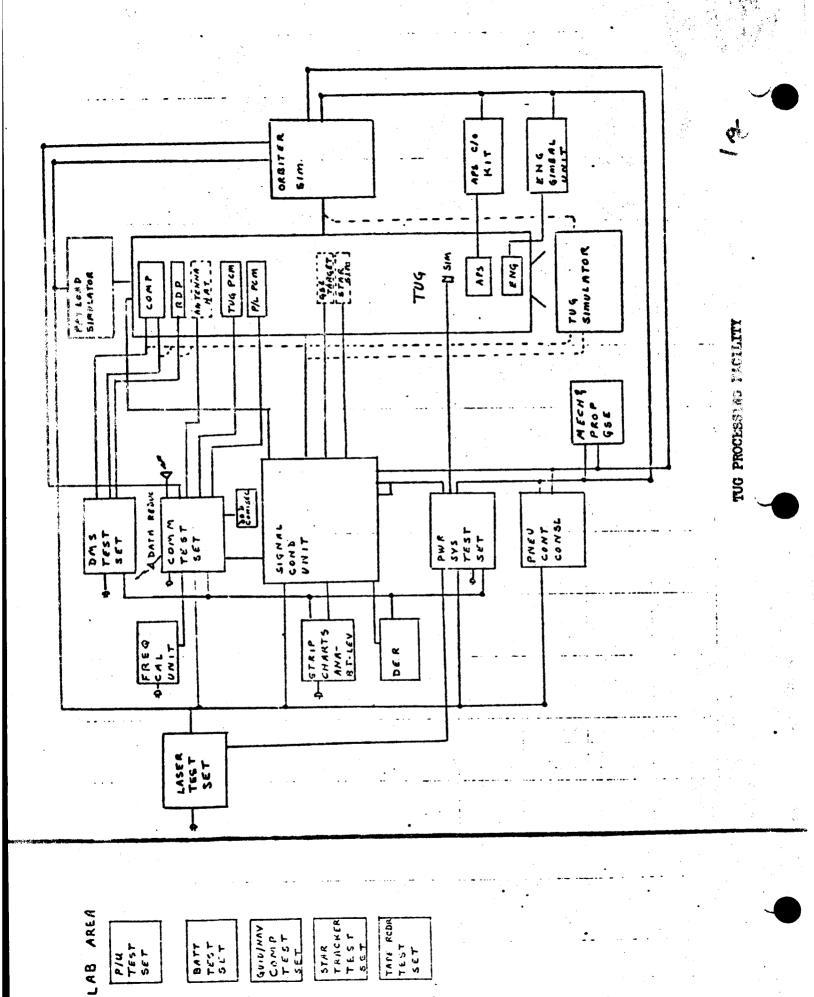
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CODE AND COMPII VALIDATE TEST SOFTWAR CONVERT FLOW CHARTS IN-TO HIGH LEVEL LANGUAGE GENERATE CSE AND TUG (TEST FLOW CHARTS) CHECKOUT PROGRAMS PRODUCTION USE OF CHECKOUT DRAWINGS PROGRAM FLIGHT COMPUTER C/O EXEC GENERATE FLIGHT COMPUTER EPINITION OF GSE AND TUG PRODUCE FLIGHT COMPUTER DEFINITION OF HIGH LEVEL CHECKOUT EXEC PROGRAM PRODUCTION USE OF FLT COMP C/O EXEC PROGRAM ACCEPTANCE TESTING OF C/O EXEC REQUIREMENTS CHECKOUT REQUIREMENTS SPECS THECKOUT LANGUAGE CEE-ING INTERFACE THE HARDWARE SPECS CHARACTERISTICS PROGRAM CSE OPERATING DEVELOPMENT AND OPERATIONS TASK FLOW CHECKOUT SOFTWARE FLIGHT COMPUTER PROGRAM-DETAILED DEFINITION OF PRODUCTION USE OF GSE ACCEPTANCE TESTING OF PROGRAM REQUIREMENTS MING CHARACTERISTICS CENERATE GSE EXEC GSE EXEC PROGRAM GSE EXEC EXEC PROGRAM PRODUCE PROGRAM ASSEMBLER REQUIREMENTS DETAILED DEFINITION OF ACCEPTANCE TESTING OF COMPILER/ASSEMBLER COMPILER/ASSEMBLER PRODUCTION USE OF GENERATE COMPILER/ GSE INCLUDING GSE PRODUCE COMPILER, ASSEMBLER COMPUTER PRODUCTION MECHANIZA-TION PHASE DESIGN PHASE E-145

# FLIGHT SOFTWARE DEVELOPMENT AND OPERATIONS TASK FLOW



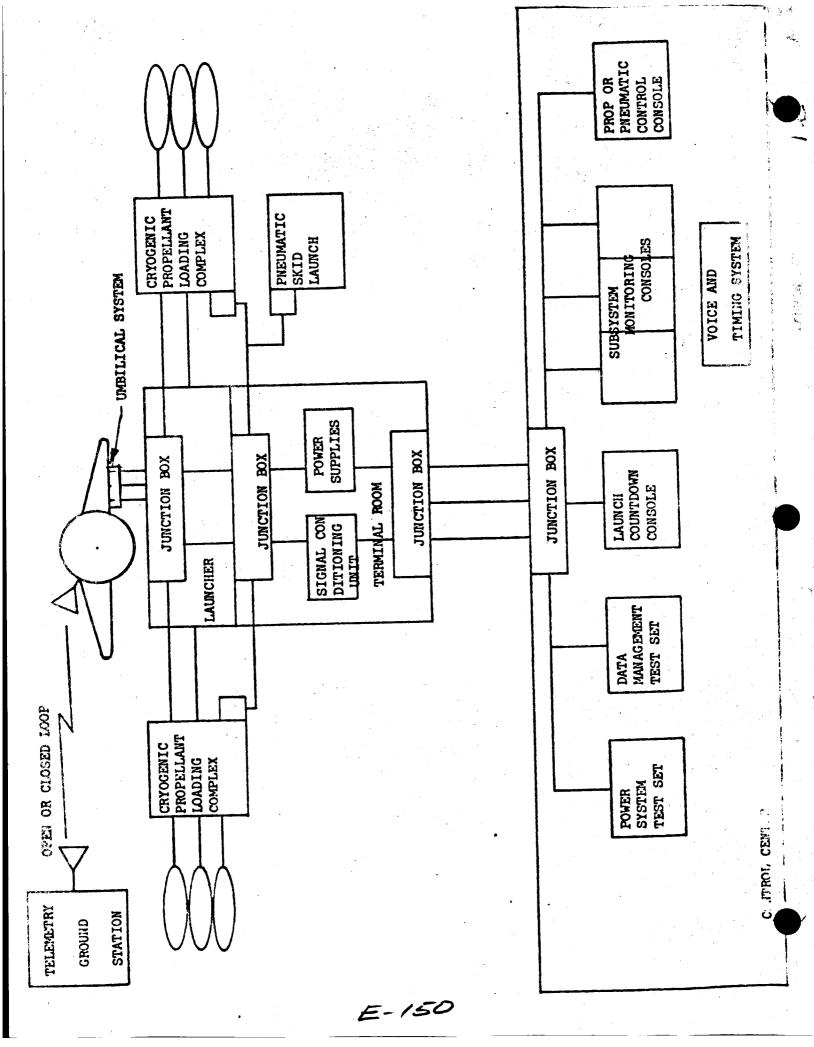


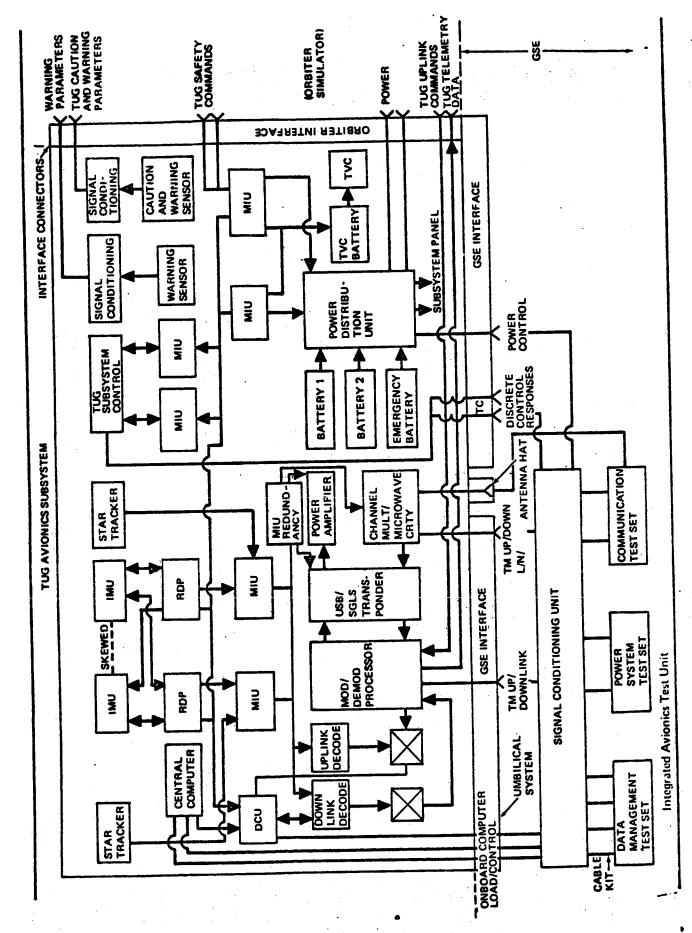


E-148

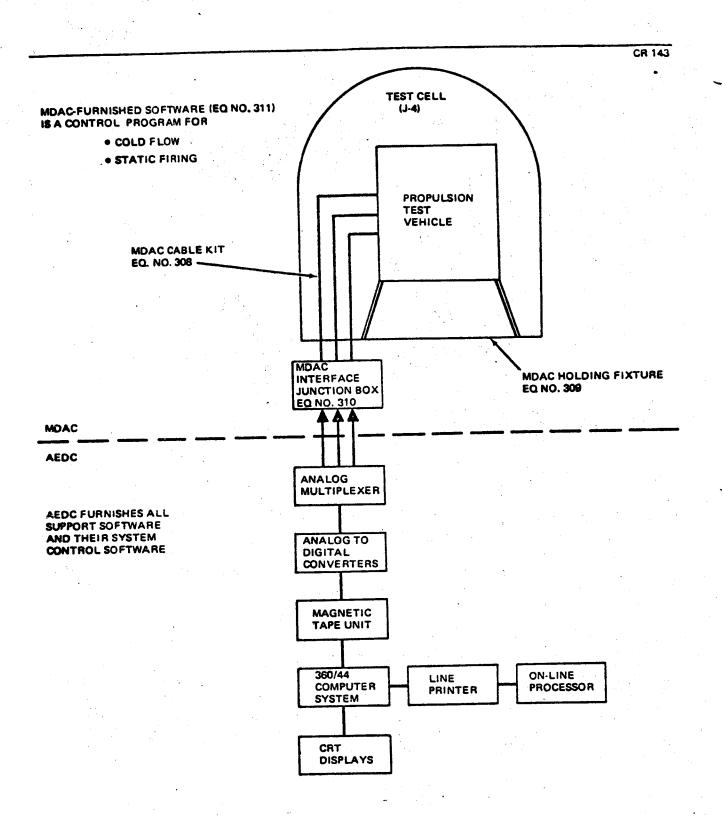
•••

ORBITER MAINTENANCE AND CHECKOUT FACILITY





18



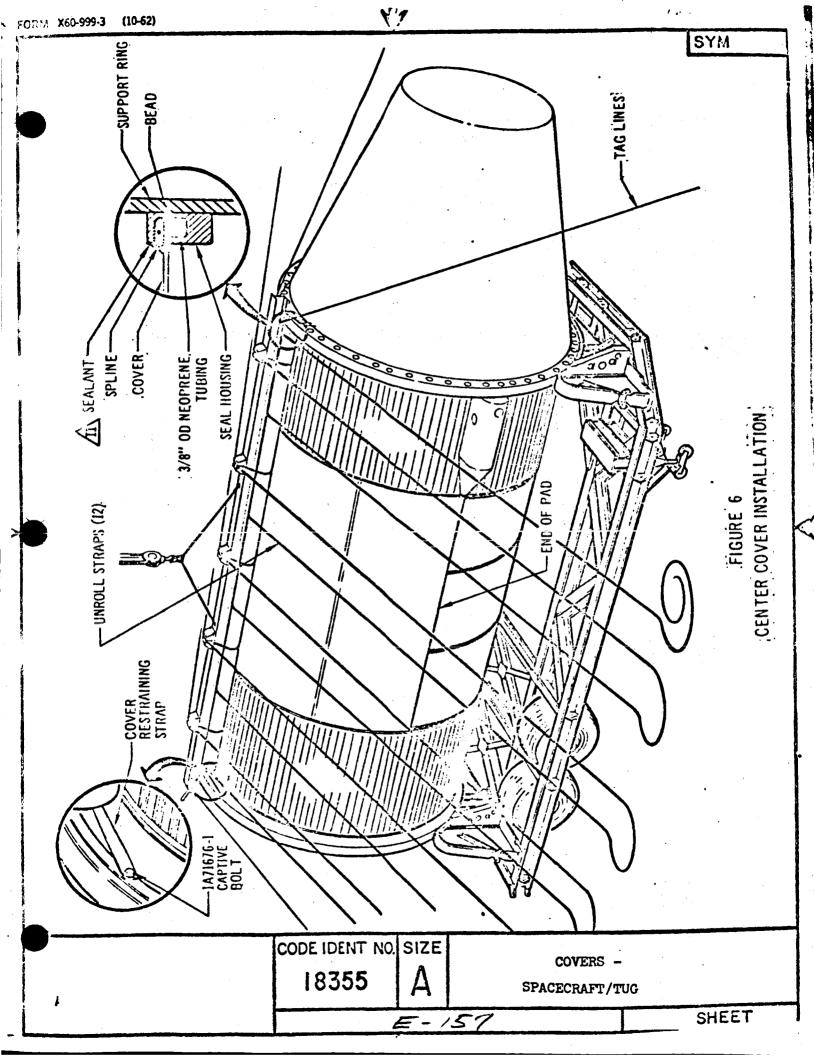
. Propulsion Test Vehicle/Ground Support Equipment Assembly

ME: APS SERVICER		EQUIPMENT NO. 113
nctional requirement	(S):	and of Burnellant System
/ Provide purging,	loading, and unloading of	APS Bi-Propellant System
QUIPMENT DESCRIPTION:		
	sting Saturn APS Servicer	
		e have Bl propellant system
10% modification		
room PER ULIT: \$	500 (NOH-R	ECURRING)
COST PER UNIT: \$_		
\$_	(RECUR	RING/YEAR)
EQUIPMENT CATEGORY:		•
NEW	MODIFIED X	AS IS
	NUMBER AVAILAB	
		•
EQUIPMENT UTILIZATION	<b>:</b>	
Functional Flow Block	LOCATION	NUMBER REQUIRED
NUMBER	REQUIRED	RIAGINES
2.1.7	Storable/KSC	1
- ·	Storable/WTR	1
	Modification cost	\$800.00
	4 Servicers	

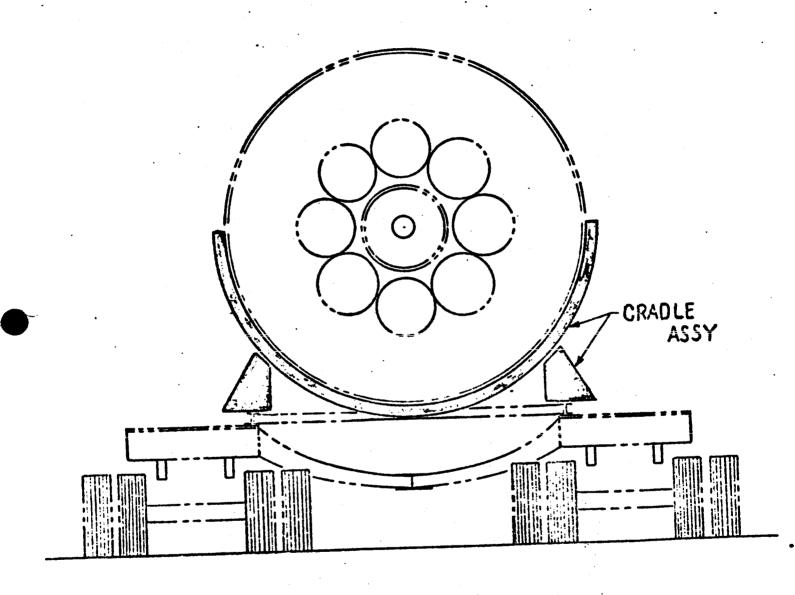
RAME:	CHECKOUT CABLE KIT		EQUIPMENT NO. 11	.O
FUNCTIO	nai, requirement(s)			
Prov	vides interconnects	between test sets,	vehicle, power, etc.	
• .				
				•
•	HT DESCRIPTION:	(novem RF signal	) required to support	t Tue
			•	4 / L
			work - 70 cable asser	
(8	0 ft) long - (35 60	pin cables; (18) 4	pin cables; (5) 39	pin
ca	bles; 7 coax cables	; (5) 24 pin cables	; breakout cables an	d general
	eakout box. Similar Si	13.500 (DES	igh and dëvelopment) urring/unit)	
EQUIPM.	CHT CATEGORY:			
3	IEM s	MODIFIED 30%	AS IS	•
1ST :	YEAR REQ'D	NUMBER AVAIL	ABLE	
EQUITME	ENT UTILIZATION:		•	•
	FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER RIQUIRED	
	1.1.5,1.1.7 ALL	• • •	•	
	1.1.8 ALL	WTR	<u> </u>	a fallerdinale
	1.1.9 ALL			
5	1.1.14			
	2.3.9, 2.4.2			
TOTAL 1	REQUIRED 1		OTAL COST \$ 5,100	

NAME: COMPONENT	PROTECTIVE (	OVERS	EQUIPMENT NO	120
functional requir	ement(s):			•• •
Provide prelaunch	h protection	for vulnerable c	omponents. Remove	ed prior to launch
and returned to	factory for	re-use.		
		·		
EQUIPMENT DISCRIP	TION:			
•		s, titanium bott]	les, and other comp	ponents subject
to ground handli				·
to ground handii	ng danage, 2.			· ·
COST	\$20	00 (DES	IGN AND DEVELOPMEN	r)
	\$ 7	00 (RECI	JRRING/UNIT)	
EQUIPMENT CATEGOR	Y:			
-		TFIED	AS IS	
			BLE	
	•			
EQUIPMENT UTILIZA FUNCTIONA			Aven 47,977	
PLOW BLOC NUMBER		LOCATION REQUIRED	NUMBER REQUIRE	
1.1.4		KSC	2	
1.1.20		WTR	8	
			·	
	·	<u>.</u>		
	<del></del>		•	
		<del></del>	•	<del></del>
<del></del>				
TOTAL REQUIRED	ħ	<b>T</b> (	YTAL COST \$ 2,800	)

ME: COVER - SPACECRA	FT FOULTMENT 1	
NCTIONAL REQUIREMENT(S)	: ental and physical protection to a s	SC while
	Tug on the transporter.	
10 13 Johnson		
QUIPMENT DESCRIPTION:  A rubber impregnate	ed fabric cover for the SC designed	to integrate
with the Tug cover	as a replacement for its forward se	ection.
		· .
<u>*</u>	3,000 (DESIGN AND DEVELO 500 (RECURRING/UNIT)	PMENT)
EQUIPMENT CATEGORY:	AC TO	
NEW X	MODIFIED AS IS	
1ST YEAR REQ'D_	NUMBER AVAILABLE	
EQUIPMENT UTILIZATION: FUNCTIONAL FLOW BLOCK HUMBER	REQUIRED	MRER QUIRED
1.1.4	KSC -2	<u> </u>
1.1.2.1	WTR	2
1.1.2.6		
2.3.6		
2.4.8		,
TOTAL REQUIRED 4	TOTAL COST \$_	2,000

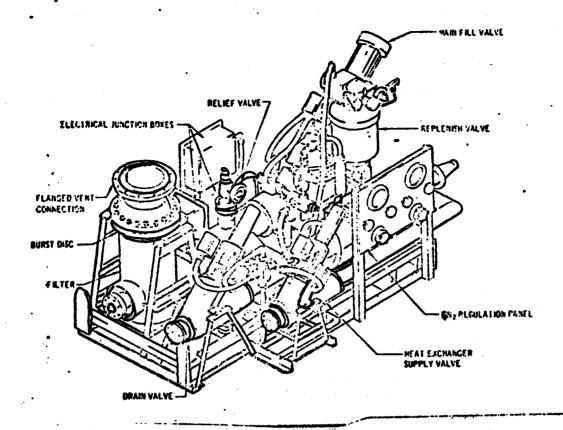


NCTIONAL REQUIR	eien(s)		nvotection	to the Tug	
		tal and physical			<u> </u>
					· <del></del>
storage in the	ne horizo	ntal position.			
	·				
EQUIPMENT DESCRIP	PTION:	•		V shama in i	hnaa
A rubber impre	gnated ny	rlon fabric cove	r fabricated	to V shape in t	onree
segments which	are asse	embled on the Tu	g by laced a	nd zippered clos	sures.
COST FER UNIT:	\$	3500	(DESIGN AND	DEVELOPMENT)	
	\$	800	(RECURRING/	UNIT)	
EQUIPMENT CATEGO	RY:	<u> </u>			
NEW	x	MODIFIED	A	s Is	•
1ST YEAR REQ'I	)	NUMBER .	AVATLABLE	0	_
EQUIPMENT UTILIZ				•	
FUNCTION FLOW BLO HUMBER	IAL	LOCATIO REQUIRE		number Required	
1.1.2.1		KSC ´		2	
1.1.22		WTR	, e		
1.1.24	•	•			, <del>.</del>
<del></del>					
			<del></del>		
		•			



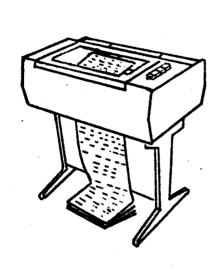
**CRADLE ASSY** 

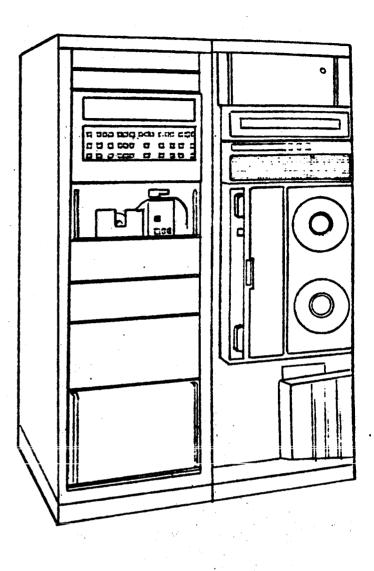
CTIONAL REQUIRE o provide a mea	ns to s	upport and rest	rain the Tug	on its transporter	
				· · · · · · · · · · · · · · · · · · ·	
		A Committee of the Comm			
QUIPMENT DESCRIP	ינסני			<del></del>	••
An intermediate	steel s	tructure to fit	between and	attach to the Tug	
and transporter					<u></u>
and cransporter	·				
·	_	100 000	(DESIGN AND	DEVELOPMENT)	
COST PER UNIT:	\$		(RECURRING/U		
	\$	07,000			
equipment categoi	<b>?</b> Y:	·			
NEA X	· ·	MODIFIED_			
1ST YEAR REQ'D		NUMBER	AVATIABLE		
EQUIPMENT UTILIZ	: HOLTA			•	
		LOCATI REQUIR		HUMBER REQUIRED	
FUNCTION FLOW BLO NUMBER				2:	•
PLOW BLO NUMBER		KSC			
FLOW BLO		WTR		2 .	
FLOW BLO NUMBER		WTR		2 .	
FLOW BLO NUMBER		WTR	<u> </u>	2 .	
FLOW BLO NUMBER		WTR	¥	2 .	



CRYOGENIC PROPELLANT LOADING COMPLEX

IAME: CRYO. PROPELL	ANT LOADING COMPLEX	EQUIPMENT NO. 125
UNCTIONAL REQUIREM		
		and IN from facility to webicle
Provide for transi	er and control of 102 a	and LH, from facility to vehicle
umbilical.		
•		
PART PAYDUM DOCODIDAT	AY •	
EQUIPMENT DESCRIPTION		rdware from Sacramento Test Center
		, umbilicals, etc.) (Utilize Shuttle
topping system.)	Same as DSV-4B-331 and	1 -332.
·		
	A 10 000	(
CORT	\$ 40,000	(DESIGN AND DEVELOPMENT)
•	\$ 20,000	(RECURRING/UNIT)
EQUIPMENT CATEGORY:		
NEW	MODIFIED X	AS IS X GFE facilities at ET
1ST YEAR REQ'D	NUMBER AV	AILABLE
		•
EQUIPMENT UTILIZATI	.ON:	
FUNCTIONAL FLOW BLOCK	LOCATION REQUIRED	NUMBER REQUIRED
NUMBER	\$1,xxfa = 1,cm	
2.4.3	KSC	
	WTR	1
<del></del>		
	· · · · · · · · · · · · · · · · · · ·	
TOTAL REQUIRED	1 .	TOTAL COST \$ 20,000





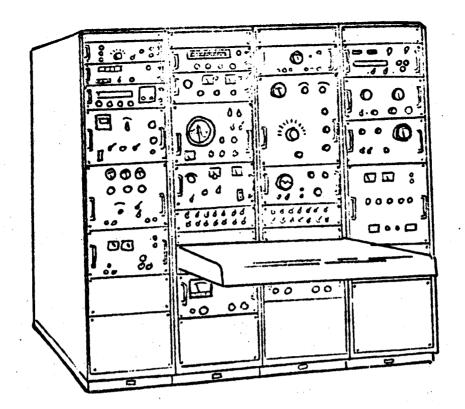


DATA MANAGEMENT TEST SET

AME: DATA MANAGEME	NT SYSTEM T/S (DMST/S	EQUIPMEN	T 110	2(
UNCTIONAL REQUIREMENT				
MCTIONAL RESOLUTION	DAS computer and mo	mitore committee :	status, ini	tials program
	tion, performs functi			
ontrol functions, in	nterface with other T	/S for dedicated	displays,	verify
elected subsystem p	arameters as program.			
WIPMENT DESCRIPTIO	N:			
₹	erfacing with compute	er for progrem ve	rification	and DMS memo
	memory loader, tape			
anel, dedicated dis	play panel for DMS fu	inction and progr	rammable dis	splay for oth
ubsystem functions	(GNC, Comm, Power, as	nd Prop.) - CRT		
OST PER UNIT:	\$ 1,033,000	(NON-RECORRING)		
	\$ 412,000	(RECURRING/YEAR)	)	
QUIPMENT CATEGORY:			•	•
NEW X	MODIFIED	AS IS_		
	NUMBER /	VAIIABLE		<del></del>
QUIPMENT UTILIZATI		•		
FUNCTIONAL	LOCATIO	<b>1</b>	NUMBER	
FLOW BLOCK NUMBER	REQUIRE	D 1	RIQUIRED	
1.1.5, 1.1.	7 ATT.			
. ;				
I.I.O ADD,				_
2.3.9, 2.4.	.3			Pariti
	<u> </u>			
	••		:.	magnet)
<u> </u>	Launch Pad/W	TR	1	

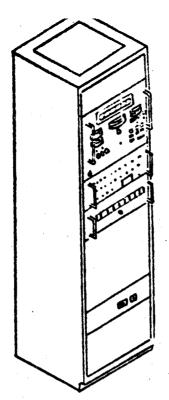
CONFIGURATION	OPTION	
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rovides adjustment, cali				
nd RF power amplifier in	stage.	·		•
QUIPMENT DESCRIPTION:		•		
Similar to DSV-4B-252				
:OST	30,000 (DE	SIGN AND	DEVELOPMENT)	
	100,000 (RE	CURRING/U	SIT)	
EQUIPMENT CATEGORY:				
new	MODIFIED	AS	TS100%_	
1ST YEAR REQ'D		,		
		:	<del></del>	
EQUIPMENT UTILIZATION: FUNCTIONAL	LOCATION		NUMBER	
FLOW BLOCK	REQUIRED		REQUIRED	
NUMBER		gradiente de la companie de la companie de la companie de la companie de la companie de la companie de la comp		
		en. Landon de la companya de la companya de la companya de la companya de la companya de la companya de la companya	The Mark of the Control of the Contr	•
	CHARLES OF THE PARTY OF THE PAR	-	1	
	Factory	-		-
	-	-		•
		-		-
				_
				•



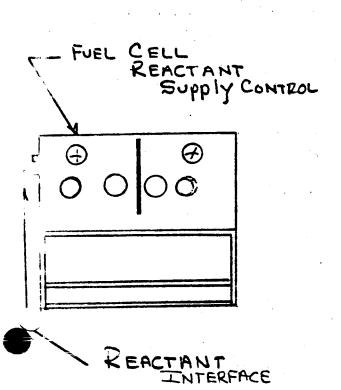
FM TRANSMITTER COMPONENT TEST SET

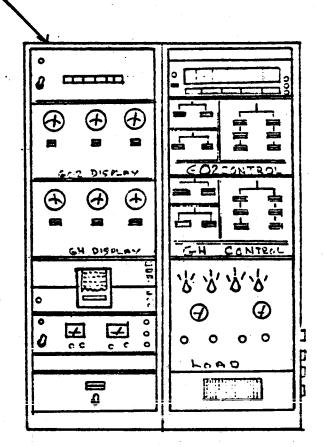
Measures frequency of I	M signals received by gr	ound stations. Contain	0.8
frequency standard devi	ice to measure and displa	y TM signals. Calibrat	tes
TM signals.			
QUIPMENT DESCRIPTION:			
Similar to DSV-4B-128			
*		AND DEVELOPMENT)  ING/UNIT)	
SQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D		ING/UNIT)  AS IS	
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK	84,000 (RECURR  MODIFIEDNUMBER AVAILABLE LOCATION	ING/UNIT)  AS IS  NUMBER	
EQUIPMENT CATEGORY:  NEW	84,000 (RECURR  MODIFIEDNUMBER AVAILABLE LOCATION	ING/UNIT)  AS IS  NUMBER	
EQUIPMENT CATEGORY:  NEW  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK	MODIFIEDNUMBER AVAILABLE LOCATION REQUIRED	AS IS	
EQUIPMENT CATEGORY:  NEW	MODIFIEDNUMBER AVAILABLE LOCATION REQUIRED	AS IS	



FREQUENCY CALIBRATION UNIT

FUEL CELL CONTROL Unit

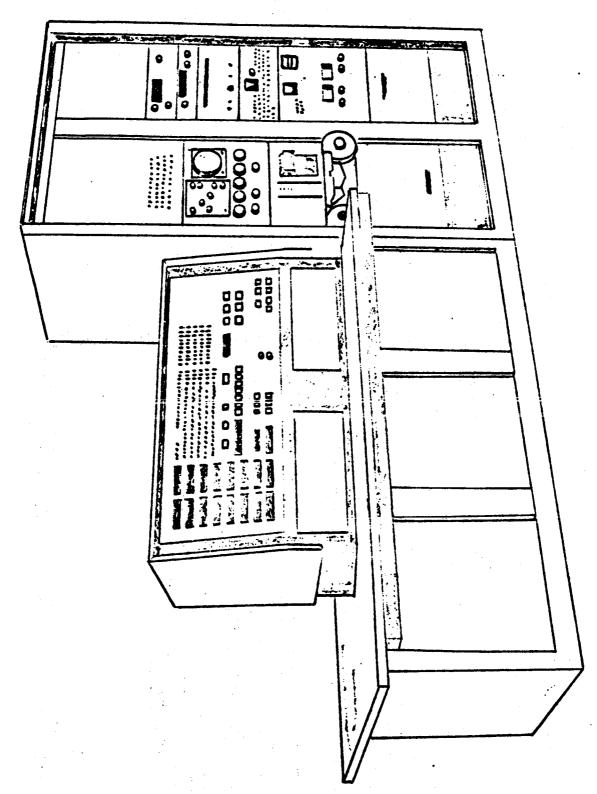




FUEL CELL CHECKOUT KIT

CONFIGURATION OPTION 3 F	OPTION 3 F
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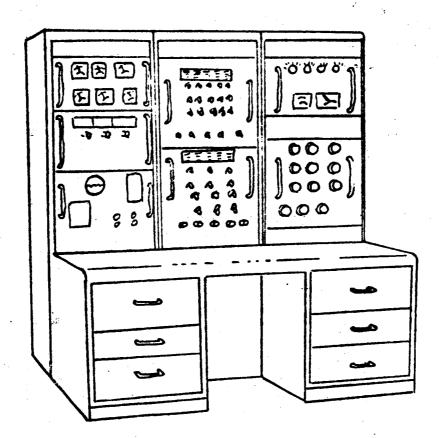
NAME: FUEL CELL CHECKOUT	KIT	EQUIPMENT NO	137
FUNCTIONAL REQUIREMENT(S)	):		
Supply reactant gases to		, provide test lo	eads for FCB,
provide signals to contro			
FCB, via coolant passages	•	· · · · · · · · · · · · · · · · · · ·	
FCB, Via Coolant passages	aim mare drughooved		
EQUIPMENT DESCRIPTION: Composed of work platform	n; fluid connections for	gaseous oxygen	and hydrogen, pressur
regulators, electronic ec			
consists of power supply			
meters, line printer, se			
meters, line printer, se	quencer, digital volumes	er, and appoint	
COST FER UNIT: \$	180.000 (NON-REC	CURRING)	
\$	75.000 (RECURE)	inc/year)	
EQUIPMENT CATEGORY:		•	
newx	MODIFIED	AS IS	
1ST YEAR REQ'D	NUMBER AVAILABLE	E	
EQUIPMENT UTILIZATION:		• • •	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	nuiger Required	Commence of the second
2.4.3(a)	KSC (Safing Area)	1	
	WTR (Safing Area)	11	
•	Factory	1	
		<del></del>	·
<u> </u>	· Administration of the second		<del>4.22.4.443</del>
		4.5	
TOTAL REQUIRED	3 TOTA	L Cost \$ 405,	



F-171

NAME: GUIDANCE AND NAVIGATION	ON TEST SET	EQUIPMENT NO. 142
functional requirement(s):		
Monitors and verifie	s checkout of IMU and GC	. It provides calibration,
alignment and simulation	of navigation programs.	Capable of simulations of all
flight programs.		
The second secon		include display panel, control
panel, oscilloscope, uni	versal counter, Digital	voltmeter, interface (DIU) assy
power supplies, digital	printer paper tape punch	, test point control panel,
downlink display panel,	etc.	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL	89_000 (RECURRI  MODIFIED	AS IS
FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED
1.1.13	KSC	1
	WTR	1
	Factory	1
		COST \$ 417,000

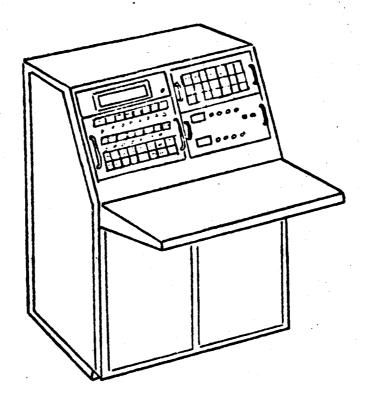
UNCTIONAL REQUIREMENT(	IMU and GC and the labore	story test equipment. Al	Lso
provides mounting of ]	MU to rate table.		
QUIPMENT DESCRIPTION:			
•	ng fixture and cables.		
CONSISTS OF THE BOTAL	ng 1120010 that once on		
cort \$	10.000 (DESIGN	AND DEVELOPMENT!	
	5.000 (RECURN		,
• • • • • • • • • • • • • • • • • • •			,
SQUIPMENT CATEGORY:	5.000 (RECURN	ing/unit)	,
SQUIPMENT CATEGORY:	5.000 (RECURR	ing/unit)  As is	٠
EQUIPMENT CATEGORY:	5.000 (RECURN	ing/unit)  As is	
EQUIPMENT CATEGORY:	5.000 (RECURR	ing/unit)  As is	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL	5.000 (RECURR	ING/UNIT)  AS IS  NUMBER	
EQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D EQUIPMENT UTILIZATION:	5.000 (RECURRED MODIFIED NUMBER AVAILABLE	ing/unit)  As is	
EQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	5.000 (RECURN:  MODIFIED	ING/UNIT)  AS IS  NUMBER	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK	MODIFIED	NUMBER REQUIRED	
EQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	5.000 (RECURN:  MODIFIED	NUMBER REQUIRED	
EQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	MODIFIED	NUMBER REQUIRED	
SQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	5.000 (RECURN:  MODIFIED  NUMBER AVAILABLE  LOCATION  REQUIRED  KSC  WTR	NUMBER REQUIRED	
EQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	5.000 (RECURN:  MODIFIED  NUMBER AVAILABLE  LOCATION  REQUIRED  KSC  WTR	NUMBER REQUIRED	
SEQUIPMENT CATEGORY:  NEW	5.000 (RECURN:  MODIFIED  NUMBER AVAILABLE  LOCATION  REQUIRED  KSC  WTR	NUMBER REQUIRED	



LASER RADAR CHECKOUT AND ANALYSIS KIT

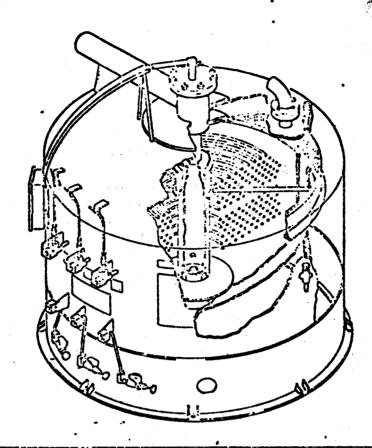
Punctional Requirement(S):		1 matra	• <b>4.2</b>
Test coolant system, chec	ek alignment, check range a	nd RCYR, check moduli	ation,
measure power and energy,	and measure servo respons	e	
			<del></del>
EQUIPMENT DESCRIPTION:			
•	ter, dichroic lens, optics	1 source target, and	test
	kit consists of radimeter,	· .	
test box, transfer meter,	, power meter oscilloscope,	and etc.	
	·		
	4		
COST \$	120,000 (DESIGN ANI	DEVELOPMENT)	٠,
COST \$	120,000 (DESIGN AND		
\$			·.
COST \$ \$ EQUIPMENT CATEGORY:	70.000 (RECURRING	(unit)	
\$	70.000 (RECURRING		
EQUIPMENT CATEGORY:  NEW X	70.000 (RECURRING	onit)	
EQUIPMENT CATEGORY:  NEW X	70.000 (RECURRING) MODIFIED A	onit)	
\$EQUIPMENT CATEGORY:  NEWX  1ST YEAR REQ'D	70.000 (RECURRING)  MODIFIED A  NUMBER AVAILABLE	onit)	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK	70.000 (RECURRING) MODIFIED A	(unit) s is	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED	VUNIT)  S IS  NUMBER  REQUIRED	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED  KSC	NUMBER REQUIRED	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED	VUNIT)  S IS  NUMBER  REQUIRED	
EQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED  KSC	NUMBER REQUIRED	
SEQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED  KSC  WTR	NUMBER REQUIRED	
SEQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED  KSC  WTR	NUMBER REQUIRED	
SEQUIPMENT CATEGORY:  NEW X  1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL  FLOW BLOCK  NUMBER	MODIFIED A  NUMBER AVAILABLE  LOCATION REQUIRED  KSC  WTR	NUMBER REQUIRED	

E. 175



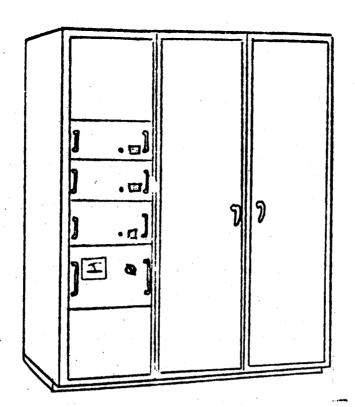
LAUNCH COUNTDOWN CONSOLE

NAME: LAUNCH COUNT	DOWN CONSOLE	EQUIPMENT NO. 145
PUNCTIONAL REQUIREMENT(	ន):	
Controls and monitors	launch checkout and co	unt down of Tug vehicle.
-	-	· · · · · · · · · · · · · · · · · · ·
and the second s		
EQUIPMENT DESCRIPTION:		
Console with intercom	and count down clock,	status indicators, alpha
numerical display and	associated circuitry.	
COST \$_	30,000 (DES	IGN AND DEVELOPMENT)
\$	20,000 (REC	CURRING/UNIT)
EQUIPMENT CATEGORY:		
new	MODIFIED	AS IS X GFE at ETR
	NUMBER AVAILA	
EQUIPMENT UTILIZATION:		•
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	Number Required
2.4.3		
2.4.4	WTR	1
		Million constitutiva and constitutiva an
**************************************		
		•
TOTAL REQUIRED		TAL COST \$ 20,000



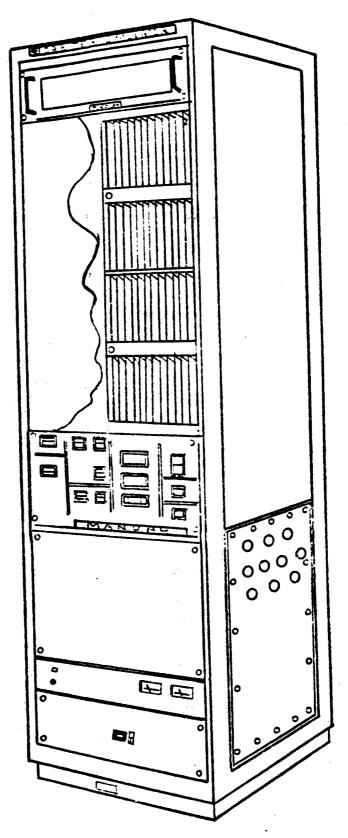
LH<sub>2</sub> - HEAT EXCHANGER

NAME: LH2-He HEAT EXCHAIN	SER .	EQUIPMENT NO. 147
functional requirement(s):	· · · · · · · · · · · · · · · · · · ·	
Provide prechilling of he	lium used for APS ta	nk pressurization or main
propellant tank pressuriz		
properties of the property of		
EQUIPMENT DESCRIPTION:		Company Mark Company and
LH2-He heat exchanger uti	lizing hardware from	Sacramento Test Center and
KSC where possible.	·	
	:	
	•	
	(2007/	IN AND DEVELOPMENT)
COST .		_
<u>\$</u>	20,000 (RECUI	RRING/UNIT)
EQUIPMENT CATEGORY:		
NEW	ODIFIED X	AS IS
1ST YEAR REQ'D	NUMBER AVAILAB	LE
EQUIPMENT UTILIZATION:		•
FUNCTIONAL	LOCATION	NUMBER
FLOW BLOCK NUMBER	REQUIRED	REQUIRED
1.1.8.2	· · · · · ·	
1.1.9.7	WTR	1
1.1.7.1		
		·
	<del></del>	
Constitution of the Consti		
TOTAL REQUIRED 1	moti	MAL COST \$ 20,000



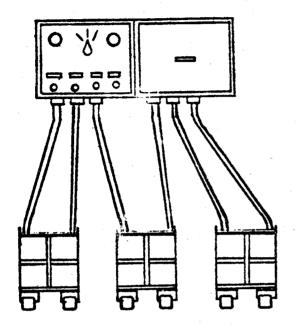
SIGNAL CONDITIONING UNIT

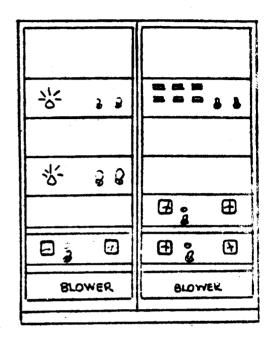
NAME: SIGNAL CONDITIONS	EIG UNIT	EQUIPMENT NO. 1	
FUNCTIONAL REQUIREMENT(S):			
Interfaces between Tug vel	nicle and GSE for signa	l and power condition	oning, and
distribution			·
•			
EQUIPMENT DESCRIPTION:			
Consists of a 3 bay conso.	le which contains junct	ion box, (1) 1932 p	cint patch bene
assembly, (10) isolation			
(1) logic power supply, a			
DSV-4B-133).	•		· · · · · · · · · · · · · · · · · · ·
	/DECTO:	AND DEVILOPMENT)	
CORT \$			
\$ <u>.                                    </u>	120,000 (RECUR	RIIG/UIIT)	
EQUIPMENT CATEGORY:		•,	
NEM x	MODIFIED	AS IS	•
1ST YEAR REQ'D	NUMBER AVAILABL	E	*
EQUIPMENT UTILIZATION:		• • •	
FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED	
1.1.5		and the second s	· 
/. 1.1.7 ALL			· 
/ 1.1.8 ALL			<b>1980</b>
2.3.9			
2.4.3	Launch Pad/WTR	11	
Children and an annual section of the section of th	and the second s		_
Carlot Constitution of the	1 mom	. 100 000	
TOTAL REQUIRED	TOTA	L COST \$ 120,000	



ORBITER SIMULATOR

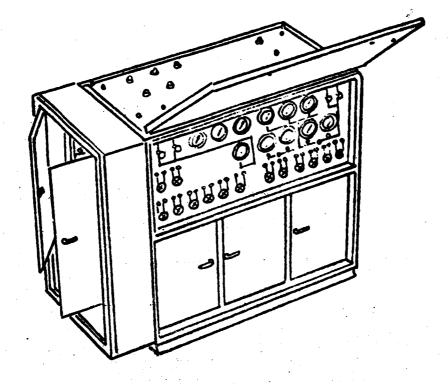
NAME:	ORBITER SIM	ULATOR			_ DOUI	184FNT NO. 149	
<b>FUNCTI</b>	ONAL REQUIREM	ent(s):					·
Func	tionally simul	lates or	biter/Tug i	nterfaces	for ve	erification of	electrical
	meters			<del></del>			
			•				
<del></del> _	· · · · · · · · · · · · · · · · · · ·	<del></del>		<del></del>	<del></del>		
EXILITE:	ENW DECEDEDAT	^\Y •			•		
-	ENT DESCRIPTION		ing anadam	decedem	and l	oad test circui	+-
<del></del>					ania Ta	Dad test circui	
Cont	ains switches	and ind	icator light	ts .			·
10%	modification d	lue to av	vionics chan	ges.			
<del></del>	· · · · · · · · · · · · · · · · · · ·		······				
COST		\$	400,000	_ (DESIG	H AND I	DEVELOPMENT)	
		\$	100,000	(Recur	KÜKG/U	(IT)	•
EQUIPM	ENT CATEGORY:						
1	NEW	M	ODIFIED	(	AS	18	
1ST	YEAR REQ'D		NUMBER	AVATLABI	LE		·
EQUIPM	ENT UTILIZATIO	on:			•		
	FUNCTIONAL FLOW BLOCK NUMBER		LOCATI REQUIR			NUMBER REQUIRED	
	1.1.7.9		TPF/KSC			1 x	
	1.1.8.9		PPF/WTR		_	1 x	
	/1.1.9.9		Factory	·		<u>l</u> x	•
	·				***		•
				•			
		··					
	<del></del>				•	•	
TOTAL I	REQUIRED	3	-	TOTA	L COST	\$ 30,000	· ·





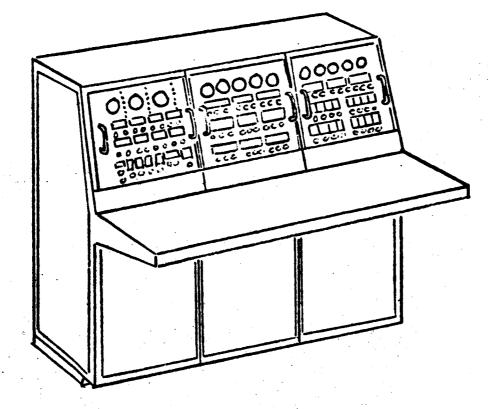
POWER SYSTEM TEST SET

nave: Power Syste	H T/S (PSTS	)	EQUIPMENT NO	155
FUNCTIONAL REQUIRE	ment(s):			· •
Provide means to 1		lls and vehicle po	wer distribution	system. Provide
ground power source	es for vehi	cle and GSE. Prov	ride emergency pow	er in event
facility power mal	·			
		_	•	
EQUIPMENT DESCRIPT	TON:			
Two bay rack of el		uipment containing	two independent	programmable pow
supplies for vehice				
programable loads				
for exergency power				
COST FER UNIT:	\$13	14,000 (KON-R	ECURRING)	
	\$	18,000 (RECUR	rinc/year)	
EQUIPMENT CATEGOR	Y:	•		
NEM X	MOI	DIFTED	AS IS	• .
1ST YEAR REQ'D_		NUMBER AVAILAR	LE	· · · · · · · · · · · · · · · · · · ·
EQUIPMENT UTILIZAS	TION:		•	
FUNCTIONAL MICH.		LOCATION	NUMBER	•
FLOW BLOCK NUMBER		REQUIRED	REQUIRED	
1.1.5,	1.1.7 ALL			, .
/ <sub>/-</sub> 1.1.8 A	LL 1.1.9 AL		•	<del></del>
2.3.9,	2.4.2			- Approximation de la Constantina
2.4.3				
		Launch Pad WTR	1	
	<del></del>	-	•	<u> </u>
	1		PAL COST \$ 48,0	00



PROPULSION PHEUMATIC CONSOLE (LAUNCH)

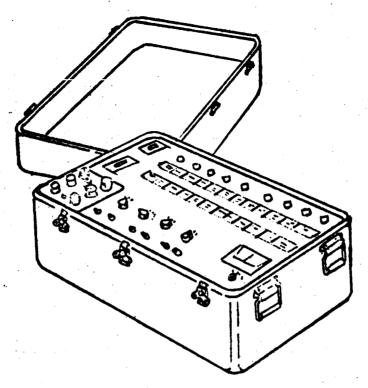
iame: preumatic skid L	AUTICH	EQUIPMENT NO. 162
unctional requirement(s)	):	
		pressurization of pneumatic
and propellant systems	for pad eneckout and ta	uneu.
QUIPMENT DESCRIPTION:		
Pneumatic console such	as DSV-4B-432A modified	for special Tug requirements.
		(
corr \$	50,000 (DESIGN	AND DEVELOPMENT)
<b>.</b>	450,000 (RECUR	RING/UNIT)
"		
EQUIPMENT CATEGORY:	· · · · · · · · · · · · · · · · · · ·	A TO THE THE
		AS IS X GFE ETR
1ST YEAR REQ'D	NUMBER AVAILABL	E
EQUIPMENT UTILIZATION:		
Functional Flow Block Number	LOCATION REQUIRED	number Required
2.4.2	Launch Area/KSC	
2.4.3	Launch Area/WTR	1 1
·		
		THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER.
	<u></u>	
		•



PROPELLANT OR PNEUMATIC CONTROL CONSOLE

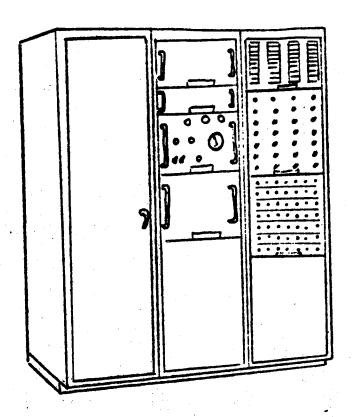
## GSE DECCHIPTION SHEAT

FUNCTIONAL REQUIREMENT(S):			
ontrols and pnounatic regula	ated gas supplies for a	rehicle pressurization of	f
neumatics and propellant sys	stems. Used for checke	out, purge, and pressure	checi
nd loading of pneumatics int	to Tug vehicle. Monito	ors propellant loading a	nd un-
oading. Capable of semi-aut	tomatic or manual load:	ing of propellants.	
EQUIPMENT DESCRIPTION:		•	
Three bay console with inte	ercom, light and indica	ators, switches, and alr	ha
numerical display, and asso	ociated circuitry. (S	imilar to DSV-43-233.)	
			:
			•
COST FER UNIT: \$ 33	9,000 (NON-REC	URRING)	
\$331	4,000 (RECURRI	hg/year)	
EQUIPMENT CATEGORY;			
•	•	•	
NEW X WTR	MODIFIED	AS ISETR	
NEW X WTR	MODIFIEDNUMBER AVAILABLE		
-			· •
1ST YEAR REQ'D			
1ST YEAR REQ'D	NUMBER AVAILABLE		
IST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK	NUMBER AVAILABLE	NUABER REQUIRED	
IST YEAR REQ'D	NUMBER AVAILABLE	nuser	
1ST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.7.1,4	NUMBER AVAILABLE	NUMBER REQUIRED	
PROBLEM TO THE TOTAL FLOW BLOCK HUMBER  1.1.7.1,4  /1.1.7.6 - 9	NUMBER AVAILABLE	NUMBER REQUIRED	
PLOW BLOCK HUMBER  1.1.7.1,4  /1.1.7.6 - 9  /1.1.8 ALL	NUMBER AVAILABLE	NUMBER REQUIRED	
IST YEAR REQ'D  EQUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  1.1.7.1,4  /1.1.7.6 - 9  /1.1.8 ALL  1.1.9 ALL	NUMBER AVAILABLE	NUMBER REQUIRED	



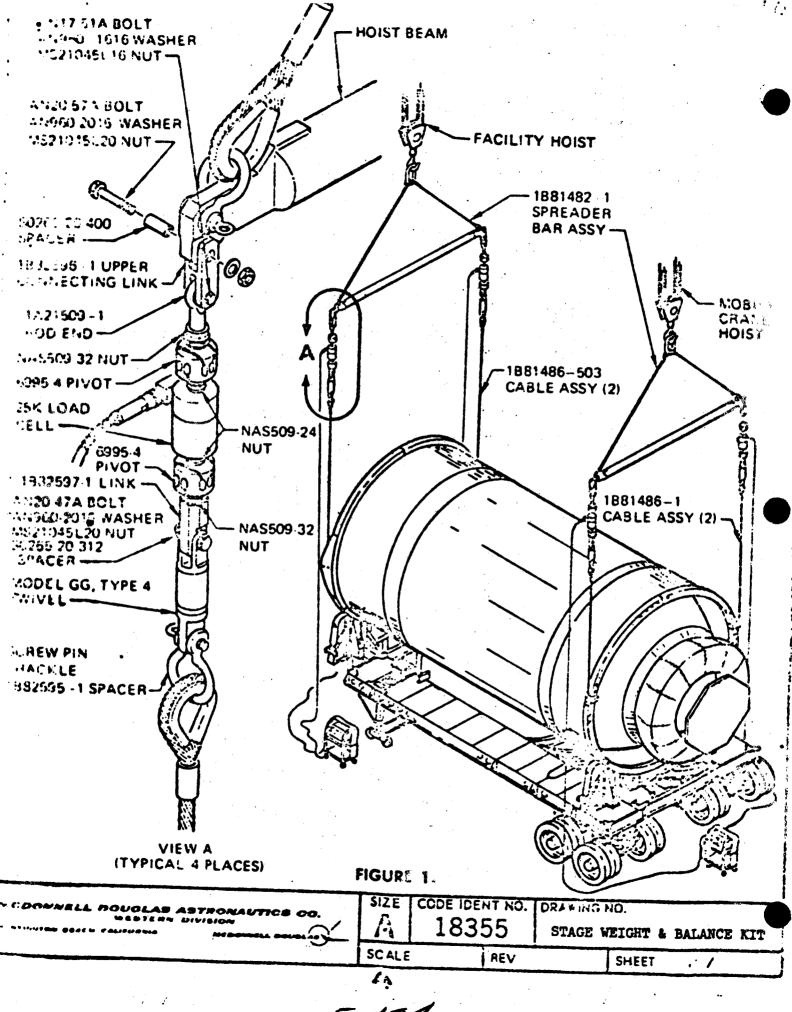
SPACECRAFT SIMULATOR

NAME: SPACECRAFT SIMULATE	OR 1	QUIPMENT NO. 168	
FUNCTIONAL REQUIREMENT(S	): Pug/Spacecraft interface i	for verification of	
electrical parameters.		-	
EQUIPMENT DESCRIPTION:			•
Portable tester contain	ing encoder, decoder and l	load test circuits.	,
10% modification due to	Avionic System changes.	•	,
TO'S MOUTH CASTON due so	AVIOUED OF FOUR CHARGOS	•	
			<del>,</del>
COST \$	150,000 (DESIGN	AND DEVELOPMENT)	
•	50.000 (RECURRI	cc/umit)	
" VCASTI ALTERATION			
EQUIPMENT CATEGORY:	MODIFIED X	40.70	
NEW	MATLIED	AS IS	
1ST YEAR REQ'D	NUMBER AVAILABLE		
EQUIPMENT UTILIZATION:		tala 🕶 in talah ing talah	
functional flow block humber	LOCATION REQUIRED	number Required	
1.1.7.9	TPF/KSC	1_x	•
1.1.8.9	PPF/WTR	1 x	
/1.1.9.9	Factory	1 x	
		• 17	
TOTAL REQUIRED	3 TOTAL	COST \$ 15,000	

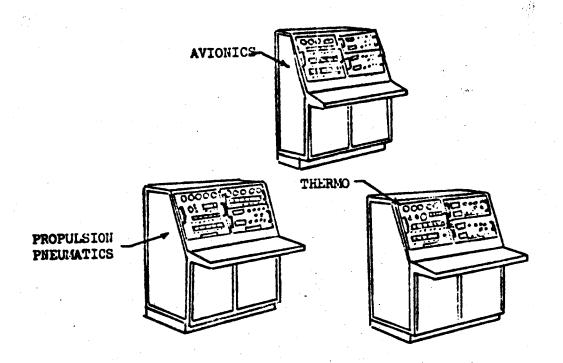


SPACE TUG SIMULATOR

NAME: SPACE TUG SIN	ULATOR	EQUIPMENT NO. 169	
FUNCTIONAL REQUIREMENT	(s):		•
Functionally simulate	s Tug electrical parame	ters for verification	of GSE, payload
and Shuttle interface	S.		
•			
			<del></del>
EQUIPMENT DESCRIPTION:			<del></del>
3 Bay console inter	facing with computer com	mlew containing louis	
	And the second s		
	t test point assembly.		c power supply.
· ·	DSV_LB_132).		
10% modification due	to Avionics System chang	es.	
COST \$_	400,000 (DESI	GN AND DEVELOPMENT)	•
<u>.</u>	100,000 (RECU	RRING/UNIT)	
EQUIPMENT CATEGORY:	<u> </u>		
NEW	MODIFIED ×	AS IS	
	NUMBER AVAILA	BLE	· ·
EQUIPMENT UTILIZATION:		•	
Functional Flow block Number	LOCATION REQUIRED	NUMBER REQUIRED	
1.1.7.9	TPF/KSC	1 ×x	
1.1.8.9			· .
1.1.9.9	PPF/WTR	<u> </u>	1
-		•	
	Factory	1 x	
POTAL REQUIRED	3 <b>To</b> T	AL COST \$ 30,000	



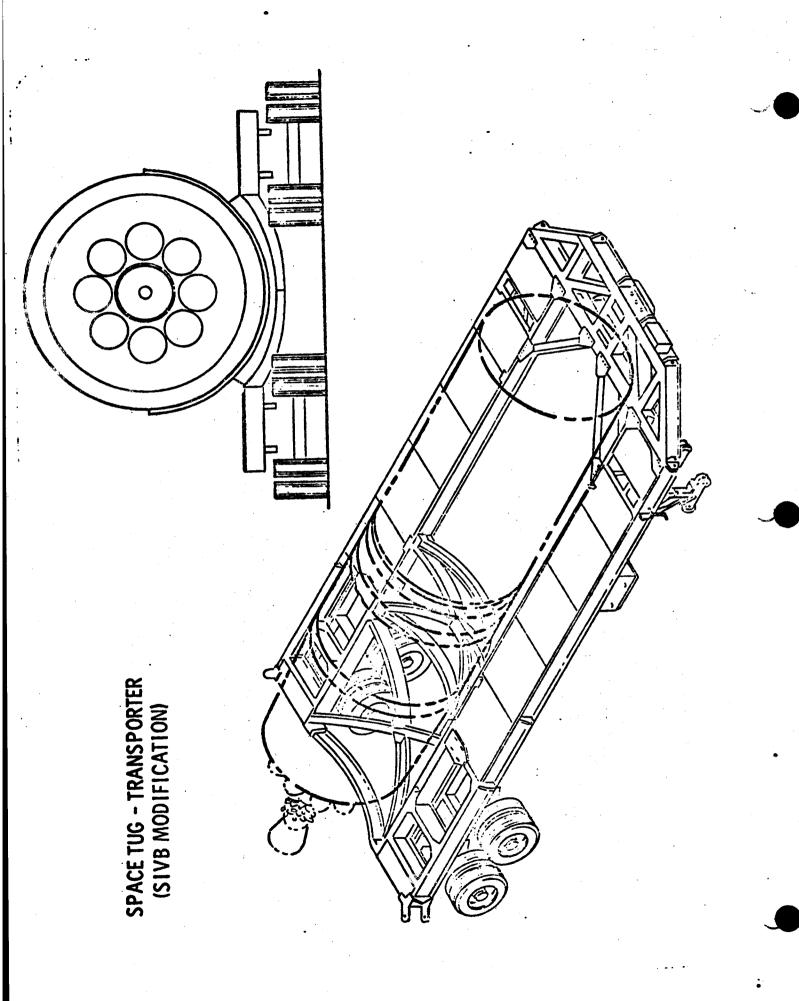
NAME: 3	STAGE WEIGH	AND B	ALANCE KIT		EGUI	PMFNT NO. 173	
FUNCTIO	nai. Require	mer <b>t</b> (s	3):		•		
<u>Determi</u>	nes weight a	nd cer	nter of gra	evity on stag	e and t	ilt table.	
•				•			
EQUIPME	NT DESCRIPT	ION:					
Similar	to DSV-7-3	21 inc	ludes elec	tronics from	DSV-4B	-31/5.	
10% mod	ification d	ue to	changes in	center of gr	avity		
							Phone with the Person which comes and was
cost	•	\$	5,000	(DESIG	en and d	EVELOPMENT)	
		\$	75,000	(RECU	RING/UN	ir)	
EQUIPME	ET CATEGORY	<b>:</b>					
N	EW		MODIFIE	10%	AS	IS	
ist y	EAR REQ'D_		m	IMBER AVAILAI	BLE		
EQUIPME	ET UTILIZAT	ION:			•		
	Functional Flow block Number			CATION QUIRED		NUMBER REQUIRED	
	1.1.15		TPI	r/ksc		l x	
	•		PPI	F/WIR	_	1 x	
		•					
					_		
							•
			المسيوسيونانيب	_			
		<del></del>					•
TOTAL R	EQUIRED		2	ro	MAL COST	\$ 15,000	



SUBSYSTEM MONITORING CONSOLES

CONFIGURATION OPTION 3F

NAME: _	SUBSISTEM MONIT	roring consoles	E	QUIPMENT NO. 176	
<b>5</b> 4 111 Am ~ A	MAY DECISEDING	n/o.)-			
	NAL REQUIREMENT				_
Monito	ors subsystem cl	heckout and count	down of avi	onics subsystems	and
disple	ays status				· · ·
•	•		•	,	
			,		
EQUIPME	NT DESCRIPTION:		•		
Consol	le with interco	n, light and indi	leators, swit	ches, and alpha n	merical
displa	ay (propulsion.	avionics, therm	o . pneumatic	3)	
<del></del>					
·			• • • • • • • • • • • • • • • • • • •	<del>,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,</del>	
COST	\$_	70,000	_ (DESIGN A	ND DEVELOPMENT)	
	\$	15,000	(RECURRIN	G/UIIT)	
EOUTPUT	ENT CATEGORY:		•		
-		MARKETER		AS IS X ETR GF	र
	EW × WTR			AS IS A BIR OF	<b>.</b>
1ST Y	TEAR REQ'D	NUMBE	R AVAILABLE _		•
EQUIPME	HT UTILIZATION:	<b>.</b>		•	
	FUNCTIONAL FLOW BLOCK NUMBER	LOCAT: REQUII		number Required	
	2.4.3	KSC			
	2.4.4	WTR		3	_
* y			· · · · · · · · · · · · · · · · · · ·		- · ·
			<del></del>		• · · .
•					•
	<del></del>		<del></del> .		-
· .			<del></del>		
momat ~	PAUTEEN	7	TOTAL C	nem & le ana	•
TOTAL K	EQUIRED		TOTAL	OST \$ 45,000	



RAME: _	Transporter		EQUIPMENT NO. 183
FUNCTIO	DNAL REQUIREMENT	(s):	
T	o give horizonta	l support and provide mo	obility to the
e	nvironmentally p	rotected Tug with a seco	ondary capability for
<u> </u>	oll and access.		
HOUT PAGE	ENT DESCRIPTION:		
		nsporter modified to inc	oomowata Satura
		gear and for provision o	or rug compatible
C	redles.		
COST PE	R UNIT: \$_	10,000 (DESI	IGN AND DEVELOPMENT)
	\$	25,000 (AEC	JRRING/UNIT)
EQUIPME	NT CATEGORY:		
	EW	MODIFIED 20%	AS IS80%
ist y	EAR REQ'D	NUMBER AVAILAB	
	NT UTILIZATION:		•
	FUNCTIONAL FLOW BLOCK NUMBER	LOCATION REQUIRED	NUMBER REQUIRED
	1.1.4	KSC	
	1.1.2.1	WTR	1
	1.1.2.2		<del></del>
	1.1.25		
	2.1.4		
•	2.3.4, 2.4.5		

UMBILICAL SYSTEM

NAME: UMBILICAL SYSTEM	<u> </u>	QUIPMENT NO. 185
FUNCTIONAL REQUIREMENT(S)	):	
Connect test and checkou	it equipment to vehicle or	to orbiter umbilical. Also,
		to orbiter umbilical. Also,
used for post flight saf	ing.	
EQUIPMENT DESCRIPTION:	•	
Orbiter-half disconnects	, ground-half disconnects	(if different from orbiter-
half), and hoses.		
•		
••••••••••••••••••••••••••••••••••••••		
COST \$	400,000 (DESIGN AN	D DEVELOPMENT)
\$	501000 (RECURRING	(UNIT)
EQUIPMENT CATEGORY:		
NEW X	MODIFIED	AS IS
	<del></del>	
1ST YEAR REQ'D	NUMBER AVAILABLE _	·
EQUIPMENT UTILIZATION:		
Punctional Flow Block Number	LOCATION REQUIRED	NUMBER REQUIRED
1.1.5	WTR (Launch pad)	1
2.3.2.2		
'2.3.9	• • • • • • • • • • • • • • • • • • •	
2.4.2		
2.4.5		
<del></del>		,
TOTAL REQUIRED	1 TOTAL C	OST \$ 50,000

F-30/

Tug operate as a system. Verifies all interfaces in a simulated flight mode approximate 40K.  QUIPMENT DESCRIPTION:  tagnetic tape or disk, listing and test procedure. Delta cost for development software to final configuration.  OST PER UNIT: \$ 89,250 (NON-RECURRING)  \$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS  1ST YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1	Simulated flight	test	(integrated sys	tem test) ver	ifies Orbiter a	nd .
QUIPMENT DESCRIPTION:  tagnetic tape or disk, listing and test procedure. Delta cost for levelopment software to final configuration.  OST FER UNIT: \$ 89,250 (NON-RECURRING)  \$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS  1ST YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL LOCATION HUMBER PLOW BLOCK REQUIRED REQUIRED  1.3.9 MCF KSC 1  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1	Tug operate as a	syste	em. Verifies al	ll interfaces	in a simulated	light
Revelopment software to final configuration.  Dest fer unit:  \$ 89,250	mode approximate	40K.		•	·	
Revelopment software to final configuration.  DEST FER UNIT: \$ 89,250 (NON-RECURRING) \$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS  LET YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL LOCATION REQUIRED  PLOCATION REQUIRED  PLOCATION REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1						
ST FER UNIT: \$ 89,250 (NON-RECURRING) \$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS	MIPMENT DESCRIPTI	ON:				
ST FER UNIT: \$ 89,250 (NON-RECURRING) \$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS	agnetic tape or d	isk,	listing and test	t procedure.	Delta cost for	
\$ 30,000 (RECURRING)  RUIPMENT CATEGORY:  NEW MODIFIED AS IS  IST YEAR REQ'D NUMBER AVAILABLE  RUIPMENT UTILIZATION:  FUNCTIONAL LOCATION NUMBER REQUIRED  PLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1					·	
\$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS  LST YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL LOCATION NUMBER FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1						
\$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS  LET YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL LOCATION NUMBER REQUIRED  PLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1					-	
\$ 30,000 (RECURRING)  QUIPMENT CATEGORY:  NEW MODIFIED AS IS  LST YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL LOCATION NUMBER FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1	oom pep tivem		89,250	AND DESCRIPTION	rua)	
NEW MODIFIED AS IS	COST FER UNIT: \$		<del>,</del>			
NEW MODIFIED AS IS  1ST YEAR REQ'D NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL LOCATION NUMBER FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1		\$		_ (RECORRING)	•	
NUMBER AVAILABLE  QUIPMENT UTILIZATION:  FUNCTIONAL FLOW BLOCK NUMBER  ACF KSC 1 2.4.1  NUMBER AVAILABLE  NUMBER AVAILABLE  NUMBER AVAILABLE  NUMBER			·			
FUNCTIONAL LOCATION HUMBER FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1						2
FUNCTIONAL LOCATION HUMBER FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1	1ST YEAR REQ'D_		NUMBER	AVAILABLE		•
FLOW BLOCK REQUIRED REQUIRED  2.3.9 MCF KSC 1  2.4.1 MCF WTR 1		ON:				
2.4.1 MCF WTR 1	FLOW BLOCK			-	** * ** -**	
	2.3.9		MCF KSC		1	•
2.4.3 Factory 1	2.4.1		MCF WTR		1	
	2.4.3		Factory		1	
	<del></del>		<del></del>			•
•				<del></del>		
			***************************************	and an investigation		•

GROUND CHEC RAME: COMPUTER PR	KOUT TUG PROCESSING FACILITY OGRAMS EQUIPMENT NO. 304	
FUNCTIONAL REQUIRED  Instrumentation sy	ERT(S): stem calibration & test. All system test. Subsystems test	
	age Tugs) Programs for ACPS, engine gimballing (sterring),	-
propulsion - press	urization, propellant utilization, engine electronics, and	
guidance Navigatio	n and control.	
EQUIPMENT DESCRIPTION Magnetic tape or	ON: disk, listing, and test procedure. 181 approximate memory	
instructions. Pr	opellant utilization 6K, APCS 20K, engine gimballing 20K,	
propulsion 40K, G	N&C 15K, instrumentation system test and control 35K, all sy	rstei —
test 45K. Delta	cost for software modification to final configuration.	_
COST FER UNIT:	\$ 200,000 (NON-RECURRING)	
	\$ 49,800 (RECURRING)	
EQUIPMENT CATEGORY		
NEW	MODIFIED X AS IS	
1ST YEAR REQ'D_	NUMBER AVAILABLE	:
EQUIPMENT UTILIZAT	ion:	
functional flow block number	LOCATION NUMBER REQUIRED REQUIRED	
1.1.8.9	KSC 1	
	WTR 1	
	Factory 1	ř
·		
***************************************		•
		•
TOTAL REQUIRED	3 TOTAL COST \$ 249,800	

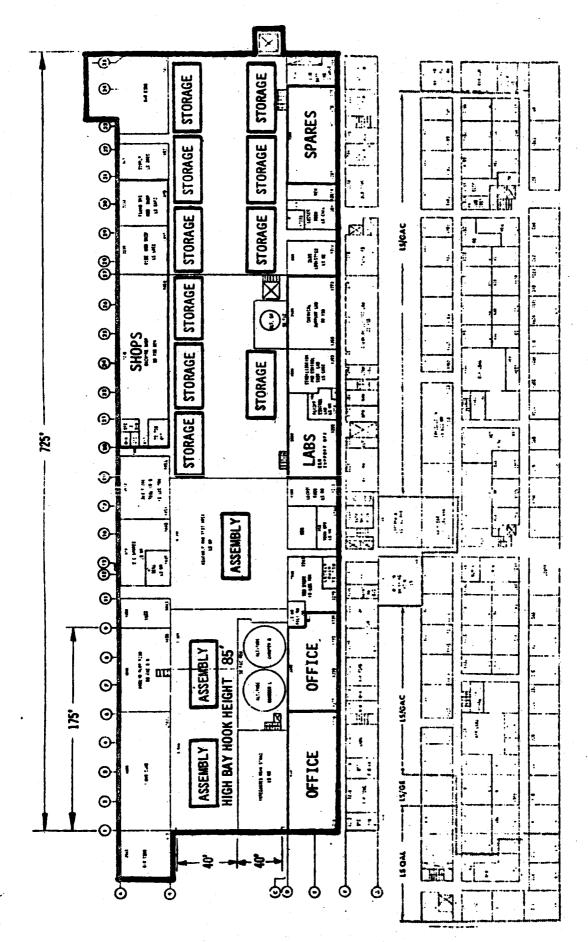
# PVT GSE DESCRIPTION SHEET WBS 32A-07-01

E COMPUTER PROGRAMS	EQUIPMENT NO. 311
ent(s):	
control the propulsion test	t vehicle testing in J4
for static firing.	
OV.	
disk, listing, and test pr	rocedure. (See attachment)
\$ 31,140 (NON-	-REGIRATNO)
-0-	
(NECC	JANING/ILAN/
	•
	AS IS
NUMBER AVAILA	ABLE
ON:	
LOCATION REQUIRED	NUMBER REQUIRED
•	
AEDC J4 Test Cel	1
	**************************************
1TO	TAL COST \$ 31.140
	entrol the propulsion test for static firing.  ON:  disk, listing, and test propulsion test properties and test properties are considered as a second constant of the constant

F-2.04

11.10 Appendix F Facility Description Sheets

NAME TUG PROCESSING FACILITY	r	LOCATION KSC	
FUNCTIONAL PURPOSE:			
A central and integrated fa	cility for implemen	ting the required	inspection, CO
and M&R operations of the T	ug and for Tug/SC n	ating. The facili	ity will provide
storage for a maximum of 12	vehicles and work a	space to permit pro	cessing 2 vehicles
n parallel. Space will be	provided for storag	se of required span	res, for a LOX cless
room and for administrative,	Q.C., and engineer	ring offices, as r	equired. A class
100K clean environment will	be maintained in a	ll but office area	s of the building.
PLOCE DIMENSIONS F MAXIMUM CEILING HEIGHT 94 CLEANLINESS LEVEL REQUIRED	T. X FT.	(AREA = 160,000 fice areas)	
FACILITY CATEGORY:		· · · · · · · · · · · · · · · · · · ·	•
NEWMC	DDIFIED5%	AS IS 95%	<del></del>
PACILITY COST:			•
\$ 500.0	00 (NON-RECURR	ING)	
<b>\$</b>	(RECURRING	YEAR)	•
	<u> </u>		
1ST CALENDAR YEAR FACILITY	REQUIRED IS		
TOTAL FACILITY COST IS \$		÷	



O & C BURDING FIRST FLOOR, KSC MT-355

SERVICE MES. 24,730 St. FT.

ANT AREA. 44,730 St. FT.

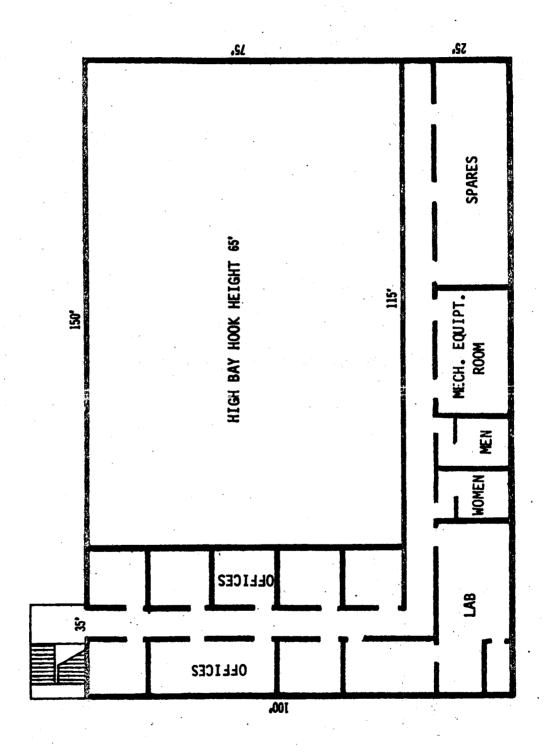
ANT AREA. 123,130 St. FT.

THORSE, 486A. 12,130 St. FT.

TOTAL 283,120 St. FT.

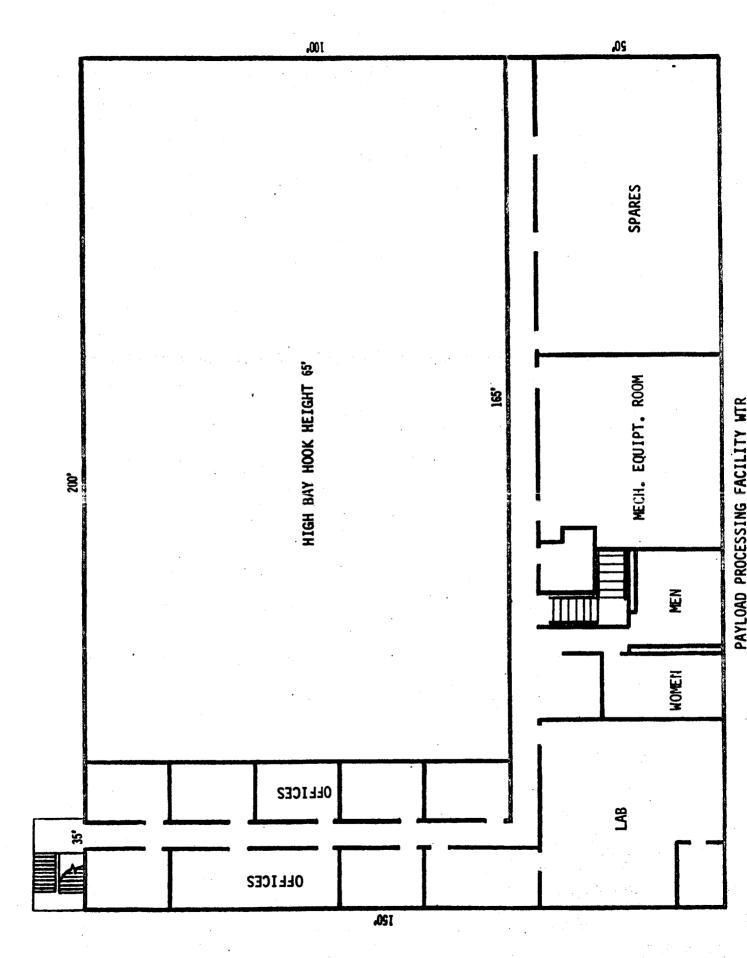
NAME DOD PAYLOAD PROCESSING FA	CILITY	LOCATION KEC	
FUNCTIONAL PURPOSE:			
	dutain accounts	· for those organitie	ne meanifeed to
A facility to implement and ma			
prepare DOD Space Craft for ma	ting with Tug.	The facility will	provide a class
100% clean environment for all	areas except th	at space required f	or administration
Q.C., and engineering offices.			
			***
PACILITY DESIGN:		TYPE FAB STEEL	
	v 150 mm		2/
FLOCR DIMENSIONS 100 FT.	XFT.	(AREA = 17,000	_F1 /
MINIMUM HOOK HEIGHT 65	FT.		
CLEANLINESS LEVEL REQUIRED	100,000 CLASS		
SECURITY REQUIRED	x YES	NO	
PACILITY CATEGORY:			
		AC TO	
NEW X MODII	TIED	AS IS	-
FACILITY COST:			•
\$ 500,000	(NON-RECUR	RTIG)	
<b>V</b>	(		•
\$	(recurring	/YEAR)	•
	•		
1ST CALENDAR YEAR FACILITY REX	OUIRED IS		
MOMAL PACTITITY COOM TO \$			

F-4



F-5

AME PAYLOAD PROCE	essing facility	LOCATION WTR	
	•		
UNCTIONAL PURPOSE			
		y for implementing the required inspec	
and M&R operation	s of the Tug and	i for Tug/SC mating. The facility wil	l provide
ork space to perm	it processing ar	nd/or storage for 2 vehicles. Space w	ill be
rovided for store	ge of required a	spares, for a LOX clean room and for a	dministrative
.C., and engineer	ing offices as 1	required. A class 100K clean environm	ent will be
aintained in all	but office areas	s of the building.	
			•
PACILITY DESIGN:		TYPE FAB STEEL	
FLOCR DIMENSIONS	150 FT. X	200 FT. (AREA = 30.000 FT <sup>2</sup> )	
MAXIMUM CEILING H	EIGHT 65	_ FT.	
CLEANLINESS LEVEL	REQUIRED 100	,000 (EXCEPT OFFICE AREAS)	
SECURITY REQUIRED	X	YESNO	
	•		
FACILITY CATEGORY	:		
NEW_X	MODIFIE	AS IS	
			•
FACILITY COST:	•		•
	\$ 750,000	(NON-RECURRING)	
		•	
,	\$	(RECURRING/YEAR)	



F-7

NAME SHUTTLE MAINTENANCE/CO I	FACILITY LOCATION KSC
FUNCTIONAL PURPOSE:	
The MCF will be modified/des:	igned to provide Tug requirements for floor space to
accommodate , I.F. verificat	ion and for a Control Center link.
PACILITY DESIGN:	TYPE
FLOOR DIMENSIONSFT	$\mathbf{FT}.  (\mathbf{AREA} = \mathbf{FT}^2)$
MAXIMUM CEILING HEIGHT	
CLEANLINESS LEVEL REQUIRED	
SECURITY REQUIRED	YES NO
PACILITY CATEGORY:	
NEWMOD	OIFIED X AS IS
PACILITY COST:	
	ASS (NOV DEGIDETIC)
<u> </u>	000 (NON-RECURRING)
\$	(RECURRING/YEAR)
•	
1ST CALENDAR YEAR FACILITY F	REQUIRED IS
TOTAL FACILITY COST IS \$	

NAME SHUTTLE MAINTE	NANCE/CO FACILITY	LOCATION WIR	<del> </del>
FUNCTIONAL PURPOSE:			
The MCF will be modifi	ed/designed to provide	Tug requirements for fl	loor space to
accommodate, I.F. ver	ification and for a Con	atrol Center link.	
·	,		
FACILITY DESIGN:		TYPE	
FLOCR DIMENSIONS	PT. XFT.	(AREA =FT <sup>2</sup> )	
MAXIMUM CEILING HEIGHT	.1		
CLEANLINESS LEVEL REQU	IRED		
SECURITY REQUIRED	YES	ОМ	
FACILITY CATEGORY:	•		
NEW	MODIFIED X	AS IS	
FACILITY COST:			
\$	10,000 (NON-RECURE	RING)	
<b>*</b>	(RECURRING)	(YEAR)	
•			
1ST CALENDAR YEAR FACI	LITY REQUIRED IS	<del></del>	
TOTAL FACILITY COST IS	\$		

IAME	LAUNCH SERV	ice struc	TURE (LAU	NCH PAD)	LO	CATION	KSC	,	
UNCT:	ional purposi	E:					•		_ •
The to	wo Service To	overs wil	l be modi	fied/design	ed to	provide	acces	s to the	he Tug in
the S	Thuttle paylo	ad bay;	ug propel	lant load,	dump,	and ve	nt cap	bility	; gas,
pover	, and commun	ication	systems a	nd space to	store	Tug pe	culiar	GSE at	point of
we.									
والمرازي والمدامر								مست برون	
	·							<u> </u>	
FACII	LITY DESIGN:								
FLOCI	R DIMENSIONS		_FT. X	FT.	(AREA			FT <sup>2</sup> )	
IXAM	MUM CEILING	height _		FT.					
CLEA	nliness leve	L REQUIRE	ED					,	
SECU	RITY REQUIRE	TD .		YES		MO			
<b>510</b> T	LITY CATEGOR	Y•							
PACI	NEW		MODIFIED	<u> </u>	•	AS IS		<del></del>	
FAC:	ILITY COST:								
		\$3	50,000	( NON-RECUI	RING)	· •			
	·	\$		(RECURRING	(YEAR)				
		•		•			**		
18T	CALENDAR YE	AR FACILI	TY REQUIE	RED IS		·			·
TOT	AL FACILITY	COST IS	<u></u>						

Shuttle payloa	d bay; Tu	g propella	nt load,	dump, and	vent ca	pability; ga	s, power
and communicat	ion syste	ms and spa	ce to sto	ore Tug pe	culiar G	E at point	of use.
	·	,				·	
		·	· · · · · · · · · · · · · · · · · · ·	<del> </del>			
FACILITY DESIG	N:			TYPE			
FLOOR DIMENSION		FT. X					
MAXIMUM CEILIN		· ·		•		-	
CLEANLINESS LE			•				
SECURITY REQUI	RED		YES		NO		
FACILITY CATEG	ORY:	• • *					·
NEW		MODIFIED	X	-	AS IS _		
FACILITY COST:			·				•
4. 4	\$35	0,000	(NON-RE	CURRING)			
			l management	ING/YEAR)		•	

NAME LAUNCH CONTROL CENT	ER		to	CATION_K	SC		
FUNCTIONAL PURPOSE:							
The Launch Control Center	r shall he	modified	to provi	de a secu	re room	for	DOD
	. BHALL UC						·
space craft.						·	
				<del></del>		·	
FACILITY DESIGN:			TYPE _				
FLOOR DIMENSIONS	PT. X	FT	. (AREA	=	FT <sup>2</sup> )	ı	
			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				
MAXIMUM CEILING HEIGHT _		Fr.	•				
CLEANLINESS LEVEL REQUIR	ED				•	•	
SECURITY REQUIRED	· 	YES		10			
•	•			•			
PACILITY CATEGORY:							
NEW	MODIFIED	X		s is			
FACILITY COST:							•
<u> </u>	10,000	(NON-RECU	RRING)	•			
\$		(RECURRIN	ig/YEAR)		•		
		· ·	·				
1ST CALENDAR YEAR FACILI	TY REQUIRE	ED IS		. :			
TOTAL FACILITY COST IS	j 						

NAME LAUNCH CONTROL (	ENTER		LOCATION	WIR
FUNCTIONAL PURPOSE:	• •			
The Launch Control Cent	ter shall be mod	ified to p	rovide a sec	cure room for DO
space craft.				
·			:	
·			•	
PACILITY DESIGN:		T	(PE	
FLOCR DIMENSIONS	FT. X	FT. (#	REA =	FT <sup>2</sup> )
MAXIMUM CEILING HEIGHT	4.			
CLEANLINESS LEVEL REQU	IRED	<del></del>		
SECURITY REQUIRED	Y	ES	NO	
FACILITY CATEGORY:	•		•	
NEW	MODIFIED		AS IS	
PACILITY COST:				
\$	_O_ (NO)	i-recurring	s)	
<b>\$</b>	(REC	CURRING/YEA	ur)	
JOM GALIMIDAD VIAN MAGTI	THE DENITED TO			:
1ST CALENDAR YEAR FACILITY COST IS		' <del></del>	<del></del>	

NAME SHUTTLE SAFING FACILITY	LOCATION KSC
FUNCTIONAL PURPOSE:	
The SF will include provisions	for Tug propellant storage and transfer and for
Tug gas, power, and communicat	ion requirements.
PACILITY DESIGN:	TYPE
	XFT. (AREA =FT <sup>2</sup> )
MAXIMUM CEILING HEIGHT	FT.
CLEANLINESS LEVEL REQUIRED _	
SECURITY REQUIRED	YES NO
FACILITY CATEGORY:	
NEWMODI	FIED X AS IS
PACILITY COST:	
•	(NON-RECURRING)
¥	(non-reconstruct)
\$	(RECURRING/YEAR)
•	
1ST CALENDAR YEAR FACILITY RE	QUIRED IS
TOTAL FACILITY COST IS \$	

and for

NAME SHUTTLE SAFING FACILITY	L	OCATION_	WTR
FUNCTIONAL PURPOSE:			
The SF will include provisions for	Tug propellant s	torage a	nd transfer
Tug gas, power, and communication	requirements.		
PACILITY DESIGN:	TYPE	٠	
FLOCR DIMENSIONSFT. X	FT. (ARE	A =	FT <sup>2</sup> )
MAXIMUM CEILING HEIGHT			
CLEANLINESS LEVEL REQUIRED		<b>W</b> A .	
SECURITY REQUIRED	YES	NO	
PACILITY CATEGORY:		•	
	¥	AS TS	
NEWMODIFIED	<u>X</u>		· · · · · · · · · · · · · · · · · · ·
FACILITY COST:			•
\$	(NON-RECURRING)		
· ·	(RECURRING/YEAR)		•
•	(12.001112110)		
1ST CALENDAR YEAR FACILITY REQUIR	ED IS		\$ 
			•
TOTAL FACILITY COST IS \$			

NAME _	STORABLE PROPELI	ART FACILITY	LOCATI	ON KBC	والمرادات المرادات المرادات
<b>FUNCTI</b>	ONAL PURPOSE:			•	
The SPS	S will provide spa	ce for mobile GS	E used in propel	lant storage and	trans-
fer ope	erations for Tug p	od, separate tan	k or integral AP	S systems.	-
					<del></del>
Telegraphic Language					
Andrew Straffer School Co.					<del></del>
PACILIT	ry design:		TYPE		
	DIMENSIONS 50	FT. Y 100	<del></del>	^	
		,,	(wax -) <u>00</u>	/	
	A CEILING HEIGHT				
CLEANLI	INESS LEVEL REQUIR	ED	<del>_</del>		
SECURIT	TY REQUIRED	YES	NO		
FACILIT	Y CATEGORY:				
NE	EW	MODIFIED x	AS IS		
PACILIT	TY COST:		•		
	\$	O- (NON-R	ECURRING)		•
	<b>\$</b>	(RECUR	RING/YEAR)		
1ST CAL	JENDAR YEAR FACILI	TY REQUIRED IS			
	ACILITY COST IS \$				•

F-16

NAME STORABLE PROPELLANT FACILITY LOCATION WTR
FUNCTIONAL PURPOSE:
The SPF will provide space for mobile GSE used in propellant storage and transfer
operations for Tug pod, separate tank or integral APS systems.
PACILITY DESIGN: TYPE
FLOCR DIMENSIONS 50 FT. X 100 FT. (AREA = FT <sup>2</sup> )
MAXIMUM CEILING HEIGHT 30 FT.
CLEANLINESS LEVEL REQUIRED
SECURITY REQUIRED YES NO
SECURITI REWOTRED
FACILITY CATEGORY:
NEW MODIFIED _x AS IS
FACILITY COST:
\$ _O_ (NON-RECURRING)
(RECURRING/YEAR)
\$ (RECORNING) I EARLY
1ST CALENDAR YEAR FACILITY REQUIRED IS
TOTAL FACILITY COST IS \$

NAME	VERTICAL	ASSEMBLY	BUILDING		LOCATIO	)NN	3
<b>FUNC</b> TIONA	l purpose		-				
Mha VAR w	dli be mo	dified as	required	to integr	rate and ins	tall GSE	
reculiar	to Tue r	equiremen	ts for mo	nitoring	storable pro	pellants.	
400				<del>,</del>			
			<u>.</u>				
	,						
			<u> </u>				<del></del> -
	PECTON.			•	TYPE	•	
FACILITY			•				
FLOCR DIM	densions _		M. X	FT.	(AREA =	FT <sup>2</sup>	,
	CEILING HE				•		
CLEANLINE	ess level	REQUIRED					
	REQUIRED		•		NO	•	,
02.000.1222	2,2,0,0,0,0		<del></del>				
FACILITY	CATEGORY	<b>:</b>					
NEW		M	ODIFIED _	X	AS IS		
_							
FACILITY							
		10,000	(	NON-RECUR	RING)		•
			(	RECURRING	/YEAR)		•
					•		
JOS CATE	WDAD YFAD	PACTI.TTY	THE THORS	IS			•
TOTAL FA	CILITY CO	st is \$		<b>-</b> .		•	

NAME _	VERTICAL	ASSEMBL	BUILDING	3		LOC	ATION_	WTR	
<b>FUNCTI</b> O	NAL PURPOS	S <b>e:</b>							
The VAI	B will be d	lesigned	as requir	red to	integr	ate and	install	GSE	peculiar
to Tug	requiremen	ts for I	nonitoring	g store	able pro	opellan	ts.		
· · · · · · · · · · · · · · · · · · ·									
	ry design:				•	TYPE _			
FLOCR !	dimensions		FT. X _		FT.	(AREA	18	F	r <sup>2</sup> )
	M CEILING								
CLEANL:	iness leve	L REQUIR	ED						
SECURI'	TY REQUIRE	D .		Y	:s	N	0		
PACILI:	TY CATEGOR	Y:	•				·		
n	EW		MODIFIED	<u>x</u>		A	s 18		
<b>FACILI</b>	TY COST:				·				•
	.·	\$ 10,00	00	(non-	-RECURR	ING)			
		\$		(REC	JRRING /	YEAR)			•
		•		•				•	
1ST CA	LENDAR YEA	R PACILI	TY REQUI	RED IS	· · · · · ·	<del></del>			
TOTAL	FACILITY C	OST IS	t						,.

AME HIGH VACUUM TE	ST FACILITY (45	57)	LOCATION	Huntsville, Ala
UNCTIONAL PURPOSE:	•			
		:		
PACILITY DESIGN:			TYPE	
PLOCE DIMENSIONS	FT. X	FT.		
AXIMUM CEILING HE	ight	FT.		•
CLEANLINESS LEVEL F			•.	
SECURITY REQUIRED		YES _	NO	
FACILITY CATEGORY:	•			·
NEW	MODIFIED		AS IS	
PACILITY COST:	•			•
nasa Dod \$	-0- 250,000	(NON-RECURI	RING)	•
\$		(RECURRING	/YEAR)	
1ST CALENDAR YEAR	PARTITMY PENITTE	ED TS		
TOTAL FACILITY COS	T IS \$			•

NAME .	AEROSPACE	ENVIRONMENTAL	CHAMBER	(MARK I	<u>)</u>	CATION	AEDC,	TULLAHOMA,	T
Funct	IONAL PURP	OSE:	•		•	·	٠		
Condu	ct PTV tes	its.							
<del></del>									
						-	·		
		·							-
PACIL	ITY DESIGN	:			TYPE		·		
FLOCE	dimension	s <u>f</u> t	. x	FT.	(AREA	. =		FT <sup>2</sup> )	
		HEIGHT							
CLEAN	ILINESS LEV	EL REQUIRED	·		•				
SECUF	RITY REQUIR	RED		YES .		NO			
FACII	LITY CATEGO	DRY:		-					
	NEW	MOD	IFIED			AS IS _		•	
FACII	LITY COST: NAS DOD	A \$1,250,00	)) (n	on-recur	RING)			•	
		\$	(R	ECURRING	/YEAR)		•		
		EAR FACILITY R		is	· · · · · · · · · · · · · · · · · · ·	•			

# 12.0 Tradeoffs and Sensitivities

This section contains specific tradeoffs and sensitivities as specified in the Data Dump Outline. Also included are additional data in section 12.7, "Other Sensitivities" which provide further information in selected trade studies.

### 12.1 Velocity Package Sizing

Because of their high energy requirements, only the planetary missions are candidates for using a large kick stage. The requirements for these missions are shown in Table 12.1-1. Only misstions 17 and 18 can be flown in a fully reusable mode. The other missions, 19 through 24, would require either flying the Tug in an expendable mode or, if possible, flying the Tug reusable with an expendable kick stage.

A schematic mission profile using a kick stage is shown in Figure 12.1-1. The Tug burns into an initial phasing orbit, (1) and then slightly before perigee does a second burn into an intermediate orbit, (2) The use of a phasing orbit is two-fold. It not only allows for minor timing adjustments, it affects a two burn departure which significantly reduces gravitational losses. Shortly after this burn the Tug separates from the kick stage-payload, (3). The Tug then retros into a return orbit with a perigee near Shuttle rendezvous altitude, (4). This is necessary on all missions, even though in some cases the Tug has not reached escape velocity, because the period of the orbit without retro exceeds Tug mission duration capability. After deployment from the Tug, once sufficient separation has been achieved the kick stage is fired, (5) sending the payload into an interplanetary solar orbit.

Using this mission profile the performance of the Tug/kick stage combination, over a range of kick stage sizes was determined. The Tug was flown off loaded, such that the combined weight of the Tug-kick stage-payload did not exceed the Shuttle deployment capability (including ancillary Tug equipment left in the Shuttle). The kick stage performance was based on Isp and  $\lambda$ 'valves consistent with current state of the art solid rocket motor stages. This performance is shown on Figure 12.1-2 for the missions of interest. By comparing the performance with the current design payload weights shown in the previous table, it can be seen that missions 22 and 24 are unobtainable over the entire range of kick stage weights. The other missions are achievable over the range of sizes, except for a small portion of mission 23.

TABLE 12.1-1

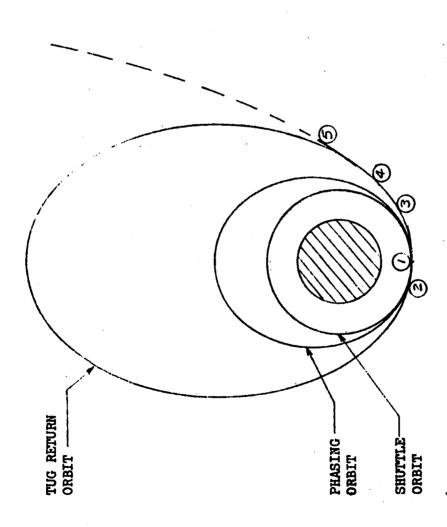
TYPICAL MISSION MODEL

FOR

SPACE TUC SYSTEMS STUDY

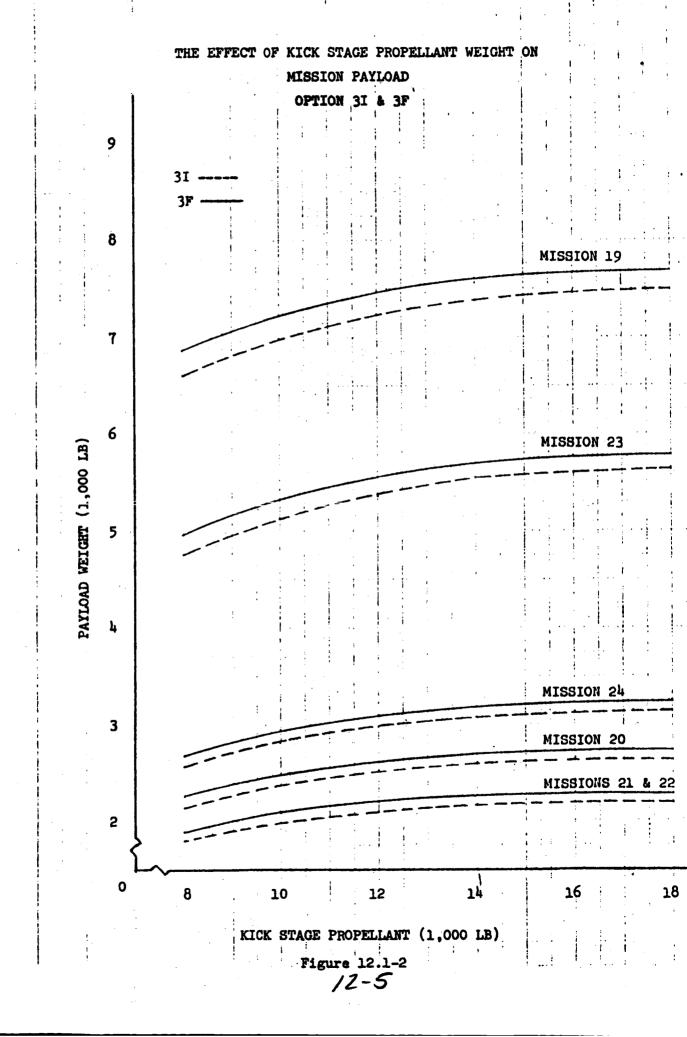
(DESCRIPTIVE DATA)

	PAYLOAD TNCL.	TNCL	H ×	V(fos)	CUR	RENT DES	IGN	TOW	LOW COST DESIGN	SIGN
	NUMBER	1.	(n.m.)	(160 n.m.)	DIAMETER (ft)	LENGTH (ft)	WEIGHT (1bs.)	DIAMETER (ft)	LENGTH (ft)	WEIGHT (1bs.)
	17			13000	10	12	1000	14	12	2000
	18			13000	10	12	2000	14	10	3300
	19			16500	12	70	5500	14	20	2900
IN KY	20			23000	10	17	006	14	14	1500
TYME	21			24000	10	15	1600	77	15	2500
a	22			24000	12	16	2500	14	82	4000
	23			18400	12	17	2000	14	16	0099
<u>,</u>	24			22000	12	17	3300	14	15	4400



() BURN INTO PHASING ORBIT
(2) BURN INTO INTERMEDIATE ORBIT
(3) KICK STAGE/PAYLOAD SEPARATION
(4) RETRO BURN INTO RETURN ORBIT
(5) KICK STAGE BURN INTO INTERPLANETARY
SOLAR ORBIT

Figure 12.1-1



Because of the strong emphasis on low costs, especially DDT&E, there was high motivation to find an existing stage within this size class. Performance alone was not the criteria for selection and other constraints had to be applied. These were stage length and thrust/time characteristics of the motor. The combined length of the Tug-kick stage-payload could not exceed 60 feet and peak longitudinal accelerations could not exceed 3.5 g's.

The only existing stage that came close to satisfying all the requirements was the Polaris A3 second stage. Its performance was adequate, it satisfied the length constraints and required only minor modifications to meet the thrust limitations.

Option 3I requires the use of a kick stage on one flight of DOD mission lla. The Polaris is well above optimum size for this mission, but can be flown in a non-optimum trajectory to satisfy the mission. This mode was chosen rather than procuring an additional smaller kick stage because it would be cheaper to buy one more Polaris than to integrate a different additional kick stage into the program.

### 12.2 Expendable Tug vs. Tug On-Orbit Assembly

The basic Option 3 program involves expending 8 Tugs (4 of Initial and 4 of Final Configuration) in the performance of 8 interplanetary missions (NASA 22 and 24). Consideration of using two Tugs to provide sufficient energy to perform the missions was made. With the Option 3 Initial Configuration significant modifications to the vehicle are required since it is limited in duration, has no docking capability and has no inter-stage structure. In the Final Configuration only the inter-stage structure needs to be added. Table 12.2-1 shows the comparison of the cost impact of adding these capabilities and the impact on the total program costs. The DDT&E costs associated with rendezvous and docking and extending duration already are necessary in the Final Configuration so the only impact in DDT&E would be the cost of the inter-stage and the moving of about \$20 millions from the final configuration to the initial configuration DDT&E.

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From the data presented in the Table it was concluded that the expendable mode was more cost effective.

OH-ORBIT ASSEMBLY (MILLIOHS)

CATEGORY

EXPENDABLE TUG (MILLIONS)

5 I Tugs = 98.6

6 F Tugs = 103.0

TUG FLEET

5 I Tugs = 98.6

11 F Tugs = 176.8

8 18 18

OPERATIONS INCREASES SHUTTLE FLIGHTS 8 ADDITIONAL

DDT&E

INTERSTACE SYSTEM

PRODUCTION

RELIABILITY IMPACT

275.4

TOTAL

18.32

0.58 0.24 307.24

12.2-1 TABLE

12-8

FLIGHT OPERATIONS

DOTEE

OPS

### 12.3 Multiple Deployment Analysis

12.3.1 Mission Accomplishment Impact

A major advantage of the STS over current expendable systems is the capability of deploying several payloads in different orbital positions. In the basic solution 3 program multi-deployments were used with both the initial and final configurations. If the configurations were allowed to deploy only one payload per mission, the number of flights would increase by 56 over the 11 year program (assuming that retrieval was allowed in conjunction with a deployment). The 56 flights would increase the program cost by about \$645 millions in operations and production by about \$16 millions.

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### 12.3.2 Multiple Payload Delivery Options

Figure (2.3.2-) summarizes several multipsyload support concepts. This comparison was done at the conceptual level only as the definition of payload support was not included in the Space Tug Systems Study.

The minimum adaptor structure was defined for the Tandem stack concept. This arrangement has the greatest impact on payload structure because the lower payloads must support the cantilevered loads of the forward payloads.

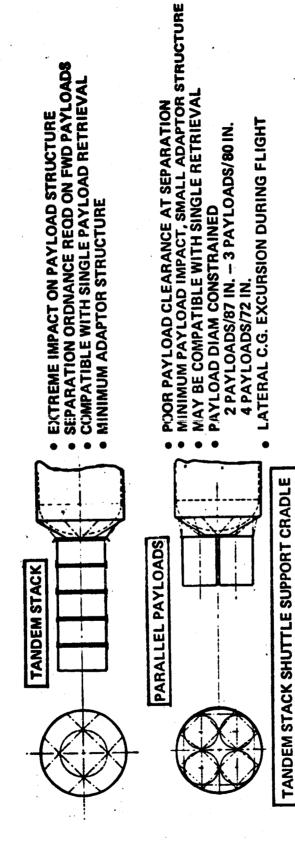
The second option, parallel payloads, minimizes the payload structural impacts but severely constrains the payload diameters.

The third option grossly complicates the Tug/Shuttle interface by creating a Shuttle/payload interface.

The final option, which is the preferred option, utilizes a retractable (collapsible) support truss. After the forward payload is deployed, the square frame portion of the support truss is expanded (enlarged) and the frame is folded back against the succeeding frame, exposing the next payload for deployment. This is repeated after each deployment. A detailed description of a similar mechanism used to enlarge the square frame is given in Volume V Section 4.3 in a discussion of an automatic variable dismeter docking system.

The DDT&E for this system is estimated to be at least equal to that of the Tug docking system or approximately \$4 million.

# MUTLTIPLE PAYLOAD DELIVERY OPTIONS

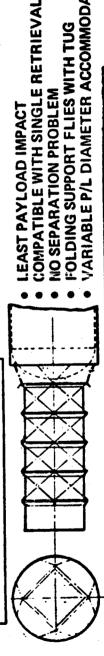


DECOUPLED FROM TUG THROUGH ASCENT COMPATIBLE WITH RETRIEVAL

PAYLOAD/PAYLOAD INTERFACE IMPACT

PAYLOAD SEPARATION ORDNANCE REQUIRED

ARGE CRADLE STRUCTURE; REMAINS IN BAY



RETRACTABLE SUPPORT TRUSS

FOLDING SUPPORT FLIES WITH TUG VARIABLE P/L DIAMETER ACCOMMODATION WO SEPARATION PROBLEM RECOMMEND RETRACTABLE SUPPORT TRUSS CONCEPT

### 12.4 Autonomy Sensitivities

12.4.1 Program Variation Identification and Sensitivity Summary

The Tug defined for Option 3F provides the capabilities associated with autonomy level III. This analysis addresses the sensitivity to other autonomy levels.

The various autonomy levels are defined as follows:

### AUTONOMY LEVEL IV

o All phases are controlled from the ground.

A portion of the mission control/sequencing is under ground control. Powered flight, contingencies and non-ground coverage control/sequencing will still be implemented on board. The ground basically has extensive on board program load/updating capability.

o Calculations are performed primarily on the ground (such as main burn and midcourse - duration and direction).

All calculations that can feasibly be performed on the ground have been removed from the on board software. The ground is responsible for vehicle attitude update (utilizing on board star tracker measurements), targeting to determine  $\Delta V$  required/burn time, tug position/velocity update during coast and possibly some redundancy management during coast.

o Ground will control final rendezvous and docking.

The acquisition guidance, closure guidance, and docking guidance will be performed under ground control. Laser radar data (if applicable) will be filtered on board.

NOTE: There is a potential problem transmitting TV data on DOD missions due to the security requirement.

o Command and Telemetry Capability

The ground (or Orbiter) will have the capability of transmitting real time hardwire uplink commands. This capability will be relatively constant for all autonomy levels since it is almost independent of flight software. All vehicles will transmit TM data.

In addition the capability for ground update of on board application programs will also not be a function of autonomy level, but the need

(or requirement) for such an update will be a function of autonomy level.

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### AUTONOMY LEVEL III

- o Ground stations provide state update during entire mission.

  The ground stations will determine vehicle position/velocity and update the flight software. The vehicle attitude update is handled on board.
- o Onboard calculations are performed for mission completion.

  All mission control/sequencing required to complete the nominal mission is resident in the on board software. The ground will have override capability via the uplink. In addition, the targeting function is carried on board. Targeting is the capability of updating the ΔV/burn time based on a predetermined mission.
- o Final rendezvous is made by on board capability.

  The target acquisition and closure guidance are performed on board.

  Radar data processing is performed on board.
- o Final docking with ground support.

  The docking guidance is provided by the ground.
- o Command and telemetry capability.

  Same as autonomy Level IV.

### AUTONOMY LEVEL II

- o Ground or navigation satellite beacons (either must serve multiple users) are acceptable.
- o Level I autonomy will be required for those orbits where ground or satellite beacons do not provide satisfactory state determination.
- o Final on board rendezvous and docking capability.

  Same as Level I
- o Command uplink override capability including payload status, redirection and retargeting of mission with telemetry down link.

Mission planning capability is added to the on board software. The

mission planning software will accept new target ephemerous/mission definition and determine a mission plan (i.e., number of burns,  $\Delta V$ 's, time, location, etc.).

### AUTONOMY LEVEL I

- o Completely independent of any man made inputs after separation.

  All nominal mission control/sequencing is performed on board. The vehicle is capable of sutonomous state (Pos/Vel/Att) update independent of any ground navigation aids. All capabilities in Level III are also included in Level I.
- o On board measurements and calculations enable missions to be completed in its entirety including all Tug and payload operations.

  Payload checkout/commanding is accomplished with vehicle software independent of required ground control although ground override capability can be provided. This requirement adds payload uplink/downlink TM equipment to the Tug.
- o Final onboard rendezvous and docking capability

  All phases of rendezvous guidance are controlled via the on board software. All sensor data is processed on board.
- o Command uplink override capability and telemetry down link.

  Same as other levels.

The sensitivities to the various autonomy levels are shown in Table 12.4-1. Autonomy Level IV results in a \$7.61 million reduction in program cost with no impact on vehicle performance. Other autonomy levels result in increased cost and decreased performance. A cost breakdown is summarized in Table 12.4-2. The savings in program cost for Level IV autonomy results from the decrease in DDT&E and operations cost. This result is significantly different from the direct developed tugs in which autonomy level IV was the lowest total cost. This difference results in a phased program because DDT&E cost for both level III and IV is incurred in a phased program whereas either level III or IV DDT&E cost is incurred in a direct developed program.

2000

TABLE 12.4-1

AUTONOMY SENSITIVITIES

	AUTONOMY LEVELS	NOW LEVELS
	J.	II
TOTAL PROJECT COST* (\$M)	192-	24.19
PAYLOAD DEPLOYED (LBS)	425 -	- 549
VEHICLE WEIGHT (LBS)	~	400
ELECTRICAL POWER (WATTS)	0	276

30.36

Does not include unscheduled maintenance and refurbishment

TABLE 12.4-2

Autonomy Cost Sensitivities (1973 Dollers in Millions)

	AU	CTIANT IMONOL	
WBS IDENT-FICATION	7.7.7	II	н
	•	``	
Avionics	-2,18	12.71	44-11
GSE	12.91	1.63	0.74
Flight Operations-NASA/DOD	-6.87	4.54	2,32
Total Project-DDT&E	76.6 -	18.84	14.58
		•	•
Avionics	- 0.02	6.30	6.30
Total Project - Production	7000	6:30	6.30
			`
Avionics (Software update)	- 1.23	2.01	81:1
GSE (Software update)	- 0.08	91.0	0.00
Flight Operations-NASA/DOD	3.48	-1.16	9/./-
Total Program Operations	7 / 7 enceta	10./	0.08
TOTAL PROJECT COST	19.4-	61.98	36.06
	peration oject-Di coftwa tware up peration ogram -	WES IDENT_FICATION  -2,18  -6.37  oject-DDT&E  oject-DDT&E  -0.02  tware update)  coftware update)  cogram-Operations  oject - Production  -0.08  3.48  oject - Operations	WBS IDENTIFICATION  -2.18 -6.71  oject - Production  (Software update)  perations-NASA/DOD  ogram - Operations  OJECT COST  WBS IDENTIFICATION  -2.18 -6.87 -6.87 -6.87 -6.82 -6.02 -6.02 -6.08

\* Does not include unscheduled maintenance

### Assumptions/Ground Rules

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As a minimum all autonomy levels require onboard redundancy management during powered flight. Since the reaction time required to switch redundant units during coast periods is less critical, redundancy management function peculiar to this phase could possibly be ground controlled.

For the higher autonomy levels (II & I), automatic payload checkout capability is added to the Tug Data Management subsystem since the vehicle may be out of contact with the ground during payload deployment.

The command override via the uplink will be implemented by one of the following methods; real time hardwire commands, real time software commands, program update, and new program load. The real time hardwire commands bypass the onboard computer and control the component directly. These commands are safety in nature and can be transmitted from the ground or Orbiter. The sender must account for the action of the onboard software during these situations. The real time software commands are executed via the onboard software. The capability of transmitting these commands has therefore been pre-planned during the writing of the onboard software. Commands that update the onboard software are similar to real time hardwire commands since they require pre-planned logic, but they affect subsequent program logic. These commands could load data required by the program, update existing data, control program mode, set flags, store program commands, etc. The requirement for providing the capability of an orbit program modification is questionable along with the implementation, so it will not be elaborated on here. The capability of loading a new program could possibly be restricted to checkout programs limited to a portion of the memory or to a complete onboard software load as the ultimate.

The real time hardwire command override capability as defined herein is not considered to be a function of autonomy level since its function is safing and reinitialization of the tug and this function is independent of autonomy level.

The requirement for real time software commands is analogous to the hardwire commands and are also not a function of autonomy level.

The requirements for program update data is a function of autonomy level although the capability of providing it is not. The requirement for ground update are reflected as changes in the application program estimates.

Program modification/load commands are not considered a function of autonomy even though they infer a level of ground support.

During powered flight the guidance (steering), flight control, state (attitude/position/velocity) determination, and subsystem control/redundancy management will be performed onboard. It is not considered feasible to perform these functions on the ground.

### 12.4.2 Configuration Variations

- o Structures no impact
- o Propulsion no impact
- o Avionics

### Data Management Subsystem

Table 12.4-3 summarizes the software requirements for the various autonomy levels. The baseline system uses a two 16 bit control computer with 24000 words of storage. Decreasing the autonomy to level IV results in a reduction of 6125 words of storage. Because of the margin, a reduction of an 8K module from the baseline computer is possible.

In addition to the software changes shown in Table 12.4-3, 3000 words of storage are required for payload checkout in autonomy levels I and II.

For autonomy levels II and I two additional 16 bit-24K computers and Data Interface units (DIU) are required to handle the increased computations and maintain the same redundancy level. The resultant sensitivities are summarized below.

	Aut	onomy Leve	el
	IV	II	I
DDT&E (M\$)	-2.18	3.36	2.12
Weight (Lb)	-2.0	40	20
Power (Watts)	Neg	156	156

TABLE 12.4-3

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	ğ	<b>2</b>	ECC TEC (ms)	<b>*</b>	ğ	ያ %	ecc the (m)	<b>%</b>	ğ	<u> </u>	ECC TOZ (m)	24	ğ	¤ R	टाटर राष्ट्र (का) १५
CATA PARATIVENT												1		ł	
Zilaliz Ki	1670	42	c	0	1670	, th	0	٥	1670	64	0	0	1670	52	•
MISSIN CRIROL	<u>α</u>	0	0	-	8	~	0	0	8	0	0		8	0	c
MATH CURROUTHES	335	•	•	•	8	•	•	•	8	•	•	•	8	•	•
UPLIER PROC	88	•	0	-	82	0	0	-	82	0	0	ed	02	0	0
HAVISATIN												ı		ı	
GROUP ALICHENT	8	•	0	•	8	ó	0	0	30	0	· 0	•	Š	•	•
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ATTITUDE HEARTE (S.T.)	150	0	•	0	38	0	0	0	12300	•	0	0	2300	0	•
And - red len har	1290	0	167	ò	250	<b>9</b>	167	~	12%	9	167	ev	120	3	167
ene l'ill die - One int	250	0	0	0	230	0	0	0	1600	0	0	0	1800	0	0
POST/JEL UTDATE - HS	ico	•	0	0	0	0	0	0	1090	0	•	0	100	0	0
GUIDANCE					j								1		
MICHINAL WOLFERS		0	٥	•	0		0	0	1 \$500	0	•	0	0	0	•
DETERORS	0	0	0	•	2000	0	•	•	2000	0	0	0	2000	0	c
FAR FLF GUID	950	24	0	0	8	42	0	0	2100	75	2	0	2001	2	270
COAST ATT PROPILE	335	0		0	335	0	0	0	335	•	0	0	335	0	C.
FLIGHT CONTROL	1660	ĸ	orr .	0	1660	ť	110	0	1660	r	110	0	1660	¢	110
SUPSYSTEM CHAPMEN			•						•						•
PRE-DEFEOY C/O	300	•	•	•	8	•	•	•	8	•	٠	٠	Š	•	•
In ILT Cont/Mont	1000	~	0	0	2002	.e	0	0	\$000	<b></b>	•	0	2000	a	0
. כ/c פאספת אס	2000	0	•	•	2000	0	0	0	2000	0	0	•	2002	0	0
TOTAL V SPETARE	124.5	237	502	214	16570	540	203	746	5/010	239	572	2,4	22510	239	5::5
FOLK CHIT, COMP, REQ'NTS	8675 9790	80 157	392 110	, m &	2,25	<b>1</b> 60	392	E E	26.55 24355	80 159	392 180	£ 8 3	2455 19035	8 %	160 160
TOTAL OF 32 NTW* COTAL OF 24 STT** TOTAL OF 15 STT**	. 9790 10769 11748	999	355	350	15925 17218 18311	\$99	355	352	24,355 261,90 28925	%	611	<b>1</b> 143	19855 21540 23526	<b>%</b>	617
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\*FIXED POINT; NO HALF WORD CAPABILITY; 24 SEC ADD; 32 BIT WORD LENGTH (TOTAL CENTRAL COMPUTER & RDP REG'MIS)
\*\*FIXED POINT; NO HALF WORD CAPABILITY; 2,64 SEC ADD; 224 SEC DOUBLE PRECISION ADD; 754 SEC DOUBLE PRECISION MULTIPLY

### Guidance Navigation and Control (GNC) Subsystem

A change in autonomy from III to IV has no impact on the GNC. Increasing autonomy to level I or II requires the addition of a horizon sensor to perform the autonomous navigation function. Because of the more frequent stellar updates required for the autonomous navigation, a gimballed star tracker is recommended for autonomy levels I & II. The sensitivities are summarized below:

END ITEM	DDT&E (M\$)	WEIGHT (LB)	POWER (WATTS)
Horizon Sensor	2.54	10	17
Gimballed Star Tracker	2.02	60	60
·	4.56	70	77

### Communication Subsystem

Autonomy levels I and II require additional communication equipment for payload checkout. This capability is provided by both hardwire and an RF link to the payload. The latter capability is requested to checkout portions of the payload equipment which can not be accomplished while the payload is attached to the Tug. A summary of the communication subsystem impacts are summarized below. There is no communication sensitivities associated with autonomy level IV.

END ITEM	DDT&E (M\$)	WEIGHT (LB)	POWER (WATTS)
Payload Interro- gator	4.79	37	22 33

### Power Subsystem

The added power requirements for autonomy levels I and II are summarized below.

Subsystem	End Item	Power (Watts)
DMS	2 Computers	156
GNC	Horizon Sensor	10
GNC	2 Gimballed Star Trackers (in place of 2 strapdown)	60
Comm	Payload Interrogation Equipment	22

The weight increase to accommodate this power increase is 49.5 lb which includes reactants and tankage. Cost increase is negligible.

# 12.4.3 Weights and Performance

The increase in vehicle weight and decrease in payload deployment associated with autonomy levels I and II is summarized below. There is no significant weight penalty associated with autonomy level III.

Subsystem	End Item	Vehicle Weight Increase (Lb)	Deployment Weight Decrease (Lb)
DMS	Computer	32	86.4
DMS	DIU	8	21.6
GNC	Horizon Sensor	17	45.9
GNC	Gimballed Star Tracker	60	162.0
COMM	Payload Interrogation Equipment	37	99.0
PWR	Reactants & Tankage	49.5	133.65
		203.5	548.55

# 12.4.4 Operations Variations

## Ground Operations

An increase to Autonomy Level IV results in a decrease in GSE software to checkout the Data Management Subsystem. There are no hardware impacts. For the higher autonomy levels (I and II) additional hardware is required to checkout the horizon sensors used for autonomy navigation. In all cases, the change in ground operations cost is negligible.

All system testing is accomplished via the Data Management system. The computer time to test the additional hardware is negligible and has little or no impact on launch operations. Our system and subsystem testing are go/no-go type tests. The launch operations are sized to handle the Tug/Orbiter functions in the time allocated for that function drive the number of personnel required at the launch site. The higher autonomy has little or no impact on launch operations since the launch personnel is available at the launch site. The autonomy cost sensitivities are summarized below.

	A.	UTONOMY LEVE	il.
	IV	ı	I
DDT&E (M\$)	· · · · · · · · · · · · · · · · · · ·		•
SOFTWARE	0.71	1.41	0.57
HARDWARE	0.0	. 2 2	.22
OPERATIONS	Neg	Neg	Neg
	-0.71	1,63	0.79

### AUTONOMY SENSITIVITIES

### FLIGHT OPERATIONS COSTS

OPTION 3

Plight operations costs were determined for each of the four autonomy levels ranging from I to IV. As shown in Table I, the autonomy levels are arranged in increasing order of autonomy going from IV to II. The autonomy level II was considered the most autonomous of the four levels investigated. The flight operations costs were divided in accordance with the WES Breakdown into recurring costs (Operations Cost 32C) and non-recurring costs (DETAE Cost 32A) for each of the four fight operations tasks of Mission Planning (WES 320-11/12-01), Flight Control (WES 320-11/12-02), Flight Evaluation (WES 320-11/12-03), and Flight Support Software (320-11/12-04).

An additional item not included in the WBS Breakdown called unused time is also shown in Table I. This item indicates the cost for unused manhours resulting from keeping a full mission control crew at both a NASA and a DOD mission control center. These unused manhours decrease with increasing autonomy level because a smaller crew is required for higher autonomous vehicles.

As can be seen from the cost data of Table I the more autonomous the vehicle is the higher the non-recurring (DDT&E) costs. Also, it is shown that for the higher autonomous vehicles the recurring (Operations) costs decrease. The delta (Δ) costs shown in Table 12.4-4 were determined using the present Option 3 vehicle autonomy level of III as a reference. Autonomy level IV gives the lowest Flight Operations costs.

Table 12.4-2

OPTION 3

AUTOHOMY SENSITIVITIES

FLIGHT OPERATIONS COSTS

TOTAL MISSIONS

LEVELS

AUTONOMY

	AI S	111	1 E	I.
	95.35	91.87	70.11	7) -06
	17.17	19.02	22.50	20.88
	47.56	42.67	38.16	39.79
	20.18	20.19	20.18	20.18
FLIGHT SUPPORT SOFTWARE	10.44	96.6	9.86	9.86
OPERATIONS PER FLIGHT (K)	263	254	251	251
NON RECURRING COSTS (M)	13.72	20.59	25.13	22.91
	6.31	12.73	17.27	15.06
	1.00	1.55	1.55	1.55
	0	0	0	0
FLIGHT SUPPORT SOFTWARE	6.53	6.31	6.31	6.31
	8.52	98.9	98.9	6.86
	3.48	0	-1.16	-1.16
A NON RECURRING COSTS (M)	-6.87	0	4.54	2.32
A FLIGHT OPERATIONS COSTS (M)	-3.39	0	3.38	1.16

Since Option 3 is a phased program an autonomy IV vehicle was used for the initial phase of the program and the final vehicle autonomy was varied from IV to II. For the case of when an autonomy level IV is used for the final vehicle the program does not have the 1.7 costs factor for phasing from one configuration to another. Therefore, since an autonomy level IV initial vehicle does not require additional DDT&E costs for phasing it becomes the lowest cost configuration.

It is also obvious from the data given in Table I that had the higher autonomy level final vehicles not used a phasing program the savings in both DDT&E and Operations, costs would have shown that the higher autonomy level vehicles to have much lower Flight Operations costs than the autonomy level IV vehicle.

#### 12.5 Onboard/Shuttle Checkout Tradeoffs

The issue to be discussed in this section is the distribution of checkout functions between the Tug/Shuttle when the Tug is in the payload bay. It is currently envisioned that the Tug will be partially operational during the boost phase. The DMS will be performing the initial navigation calculation as well as monitoring subsystem status. Telemetry data will be accessed by the DMS and transmitted to the Shuttle.

The navigation optical sensors, rendezvous/docking sensors, communication transponders, and power sources will not be active during boost.

The vehicle control software will contain the fault detection/isolation logic required to manage the subsystem redundancies, therefore the portion of the Tug that is operational will be checked out in the normal process of control. As an example the DMS computer will be periodically executing computer diagnostics as part of its normal control cycle. Prior to leaving the payload bay a subset of the following checkout functions could conceivably be performed.

- 1) Checkout of the non-active Tug LRU's (i.e., star tracker, transponders, etc.)
- 2) LRU level fault isolation. This level of fault isolation is not always required during the mission.

The checkout of the non-active LRU's could be accomplished by executing Shuttle resident checkout programs, normal Tug control software, or Tug resident checkout programs.

The following general Tug/Shuttle operating concepts are recommended:

- 1) Tug checkout will be accomplished by executing the normal Tug control software.
- 2) The Tug control software will perform fault detection but will normally only isolate to the level at which the redundant elements can be switched.

(NOTE: In some cases it may prove advantageous to isolate to a lower level in order to increase the confidence level of isolating a failure or to simplify the software required.)

- 3) The results of the Tug software fault detection/isolation algorithms will be transmitted on the downlink.
- 4) Subsystem performance data will also be transmitted on the downlink.
- 5) The Shuttle will have access to the Tug TM data and can evaluate the Tug performance based on both a software and operation interrogation of this data
- 6) The Shuttle can exercise the normal uplink control over the Tug software.
- 7) Checkout routine other than those required for subsystem control will be carried in the Shuttle and executed via the proposed 1 Mi Shuttle/Tug interface. This interface would provide the Shuttle with parallel access to the Tug command/control busses and therefore must be closely controlled. The need for this level of checkout is still somewhat undefined at this time and needs further investigation. This capability is a candidate for phasing.

In summary it would appear that the majority, if not all of the required Tug checkout software will be incorporated in the normal control software and that the Shuttle will primarily monitor the Tug operation and exercise uplink control.

#### 12.6 Dump Versus Land Full Abort

This trade study will address the features, characteristics, benefits, and liabilities of the major choices to dump any or all of Tug cryogens versus the choice to dump no Tug cryogens and to design the Tug to contain the cryogens through a normal landing. The key basis of comparison will be the payload weight penalty, including the fractional weight reduction impact on payload capability from added Orbiter weight on either a geo-synchronous deployment mission or on a round-trip mission. The payload weight penalties will be assessed against a hypothetical Tug design lacking any abort provisions. The weight differentuals or "deltas" will then be available to compare these options. The suborbital abort mode III is used as reference for this study due to the greater time constraints and greater significance in terms of design impacts. Thus, a Tug designed to meet Suborbital Mode III abort constraints will meet all abort conditions, if the porting provisions for orbital thrust-settled cryogen release are also provided.

The weight comparison resulting from this study and some key conclusions and recommendations are shown in Table 12.6-1. The compelling conclusions which lead to the selection of LO<sub>2</sub> dumping only are a payload weight reduction penalty of 1.526 lb for land full, 449 lb for sequential dump of LO<sub>2</sub> and LH<sub>2</sub>, and 414 lb for simultaneous dumping of LO<sub>2</sub> and LH<sub>2</sub>,

In addition, the land full option, although is the most simple in terms of flight operations, (1) imposes an unacceptable CG incompatibility for stable aerodynamic flight and landing, (2) imposes serious safety questions during return flight, landing and post-landing operations, and a major landing abnormality or impact could seriously threaten the structural integrity and result in ground safety hazards with both LH<sub>2</sub> and LO<sub>2</sub> on board.

TABLE 12.6-1

## ABORT STUDY ASSESSMENT

			DUMP CRYOGENS	S
	LAND FULL	> ====================================	L02 A	LO <sub>2</sub> AND LH <sub>2</sub>
		3 IN. LINE	SEQUENTIAL 3.5 IN. & 5 IN.	SIMULTANEOUS 3 IN. & 5 IN.
A TUG WEIGHT (LB)	+806	+144	+177	+164
A ORBITER WEIGHT (LB)*	+64	+340	+1303	+1297
A PAYLOAD WEIGHT (LB)	· · · · · · · · · · · · · · · · · · ·	·-·		
ROUND TRIP**	-815	-178	-307	-294
GEOSYNCH DEPLOY***	-2015	-489	-938	-903

## LAUNCH FULL, LAND FULL

SAFETY ASPECTS QUESTIONABLE

CANNOT ACCOMMODATE CRASH LOAD FACTORS (ABORT AND CRASH LANDING ARE NOT CONCURRENT COMDITIONS FOR THIS STUDY)

LANDING CG OUTSIDE OF JSC 07700 PROFILE RANGE

## DUMP SYSTEMS

SUBORBITAL DUMP IN MODE III ABORT (T +116 SEC OR LATER)

SIMULTANEOUS LH2 DUMP AND LO2 DUMP DEPENDS ON TIME AVAILABLE ABOVE 110K FT SEQUENTIAL DUMP IS PREFERRED WHEN TIME AVAILABLE, FOR SAFETY MARGIN SIMULTANEOUS DUMP SAFETY DEPENDS ON ATMOSPHERE PRESSURE AND OUTLET PORT SEPARATION PAYLOAD WEIGHT IMPACT & CG BEWEFIT CONTRIBUTE TO LO, DUMP PREFERENCE CONTRIBUTE TO LO2 DUMP PREFERENCE

LO, DUMP RECOMPENDATION:

# \* INCLUDES ANCILLARY EQUIPMENT

AMPL = - [AWTUG + 0.1 (AWORBITER)] FOR ROUND TRIP \*

ΔWPL = - [ΔW<sub>TUG</sub> x 2.5 + 0.38 (ΔW<sub>ORGITER</sub>)] FOR DEPLOY TO GEOSYNCH DRBIT \*\*\*

The return of LH<sub>2</sub> alone in a pressure-vent-limited tank is considered an acceptable ground safety risk for normal landing and the landing weight is very low with LH<sub>2</sub> on board. The Orbiter would be heavier by \$43,000 lb or more for a land-full condition. Moderately high landing g-forces or minor impacts would not necessarily threaten Tug structural integrity nor ground crew safety. The remaining risks of LH<sub>2</sub> return are balanced against the probability of a suborbital abort versus the larger possibility of an orbital abort, for which LH<sub>2</sub> dumping either with or without Helium purging is planned. The final argument is that containment of LH<sub>2</sub> at reduced pressure (18 psia or less) is an inherently simpler and safer mode of operation then the more complex and constrained mode of LH<sub>2</sub> dumping below \$400,000 ft in a fast return to launch site.

#### Option 1 - Dump LO2 Only and Retain All of LH2

This is the selected mode of operation, and is described in detail in Volume 5. Sections 5.2.4.5 and 5.4. The time available for LO<sub>2</sub> dump is much greater than required and can be initiated at any time after the abort decision is made. Thus, the least time available is from T+251 to landing at T+1.241, less 60 sec during MECO and ET jettison, or 930 sec. The benefits of early dumping in terms of 43.000 lb of potential weight reduction and the resulting increase of Shuttle AV were discussed in Section 6.4. A AV increase of 1.7% in an early abort (T+115) or 0.4% in a late abort (T+251) are appreciable in terms of proportionally extending the orbit-to-orbit thrust margin. It is also necessary to dump at least 20% of the LO<sub>2</sub> before external tank jettison and return to aerodynamic flight, due to CG constraints. Therefore, LO<sub>2</sub> dumping should be initiated immediately after an abort decision is made.

#### Option 2 - Land Full - No Cryogen Dumping

The primary factors for and against a land-full option were summarized above, and the additional weight data is provided in Figure 12.6-2 in support

of the summary chart, Table 12.6-1, above. The weight impacts are chiefly the result of "beefing up" the Tug tank and supporting Tug structure, with additional weight for horizontal fill and drain provisions for the LO<sub>2</sub> tank.

The CG incompatibility for return flight and landing is a compelling factor against a land-full option. A heavy payload or off-loading of the LO<sub>2</sub> tank would be necessary to restore compatibility, but this would prevent accomplishment of the round-trip and retrieval missions, and is therefore unacceptable.

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ജ FWD SUPT FRAME AND FTGS LO2 TANK SUPT RING LH2 TANK SUPT RING - STRUCTURAL SHELL

LH2 TANK SUPTS

LH, TANK

O LANDING LOAD FACTORS CONTROL

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AFT ATTACH FTGS

- LO2 TANK SUPTS

-LO, TANK

O SAFETY FACTOR = 1.4

Figure 12.6-2

#### Option 3 - Dump Both LO2 and LH2

Two sub-options for LO<sub>2</sub> and LH<sub>2</sub> dumping in a suborbital abort were identified and discussed briefly in Volume 5, Section 2.4.5 with respect to the LH2 cryogen handling options listed in Table 12.6-1. These are Option 3A - Sequential Dumping of LO<sub>2</sub> and LH<sub>2</sub> and Option 3B - Simultaneous Dumping of LO<sub>2</sub> and LH<sub>2</sub>. The sequential dump option is the more difficult and the required analytic data also provides for the simultaneous dump option. Both options will be discussed and conclusions will be drawn for comparison. The payload weight penalties will be developed and summarized with the Dump  ${\rm LO}_2$  only and the Land Full options.

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#### Option 3A - Sequential Dumping of LO and LH2

Sequential dumping of both  ${\rm LO_2}$  and  ${\rm LH_2}$  is most severely constrained by the time available from the late abort decision (T+251) to 30 seconds prior to Main Engine Cut off (MECO) and from 30 seconds after MECO until 110K ft altitude is reached, where LH2 dump termination is mandatory. This most constrained case will be addressed to produce the abort hardware requirement for all Tug designs. The abort trajectory which applies to the late Mode III abort case is shown in Figure 12.6-1. The pertinent data is listed in Table 12.6-2.

Table 12.6-2

#### MISSION ABORT DATA

Mode III Abort - Suborbital

Easterly Mission with 65K lb total for Tug/Payload

Late Abort Decision

All events occur below 400K ft in sensible atmosphere

Abort Start: T+251

Dump Initiation: T+251

Dump Termination: T+530.9

Available Dump Time: 279.9 seconds (main engine operating)

MEBO, ET Jettison: T+560.9

Dump Initiation: T+590.9

LH<sub>2</sub> Dump Termination (110K ft): T+726 or earlier

Flight Altitude of 50K ft: T+986

Landing: T+1241

Available Dump Time <135 seconds for LH2 during glide

Available Dump Time: 650 seconds for LO2 or 515 seconds after LH2 Dump Termination

ABORT STARE		592 SEC X 560.9 SEC	ORBITER	1 2 3 h 5 6 7 8 9 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
	HEADING REVERSAL		25S 986	1241 350 1	
P.00	300	LILINDE - K	NA NA	C	

0 TA CAR = 251 CEC

o Inplant Manburak O EASTERLY MISSION

SCREW OF C

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o 2 Main Engines AT 100% EPL

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IN ORBITER ASCENT ABORT WORS III -- ANTITUSH-THADLITY PROFILE

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Applying these time constraints to the data in Figures 12-2, -3, and -4, the dump line size requirements are derived and listed in Table 12.6-3.

n/ Table 12.6-3

#### DUMP-LINE SIZE REQUIREMENTS

Time	Maria Outlan		* ************************************
100% Dump	Tug Option	<u>10</u> 2_	<u>rh</u> 5
135 Sec	1	5.4 Inch	4.7 Inch
	2	5.9	5.0
	3I	5.4	4.7
	3F	5.6	4.9
280 Sec	1	3.9	3.4
	2	4.3	3.7
	3I	3.9	3.4
	3F	4.0	3.5
515 Sec	1	3.0	2.6
	2	3.3	2.8
	3I	3.0	2.6
	3F	3.1	2.7
650 Sec	1	2.7	2.4
	2	3.0	2.5
	31	2.7	2.4
	3F	2.8	2.5

Liquid oxygen can be dumped for a longer time than LH<sub>2</sub>, essentially down almost to landing, and a 3.0-inch line spans all Tug options. Assume a 3-inch LO<sub>2</sub> abort line is selected:

Tug Option	<u>Time</u>
	100% Dump (LO <sub>2</sub> )
<b>`</b>	505 Seconds
2	635 ·
31	505
3F	530

From the late Mode III abort trajectory, the duration of Main Engine operation is 280 seconds. With a 3-inch LO<sub>2</sub> dump line, we can dump 280/635 = 44.1% of LO<sub>2</sub>.

NOTE: Unporting need not occur to 50% of LO2 dump, depending on

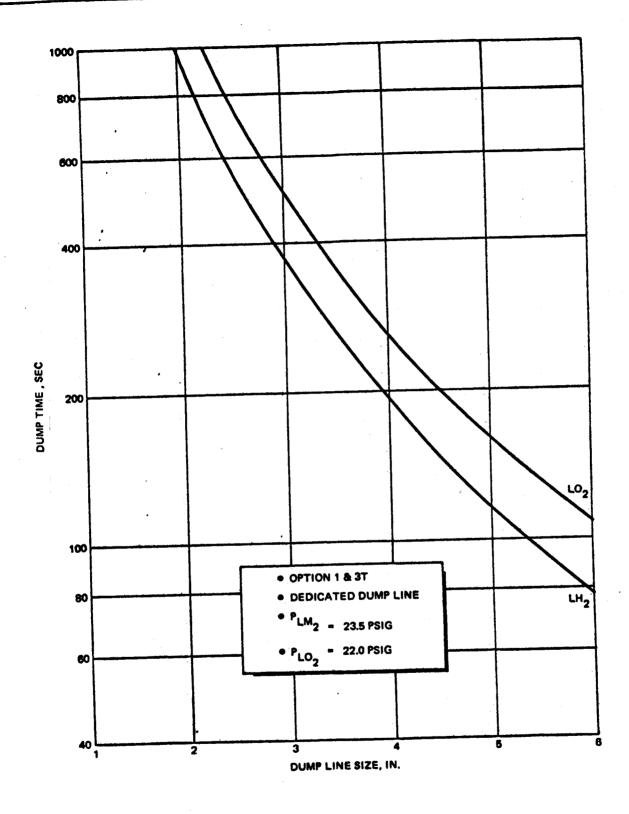


Figure 12.6-2

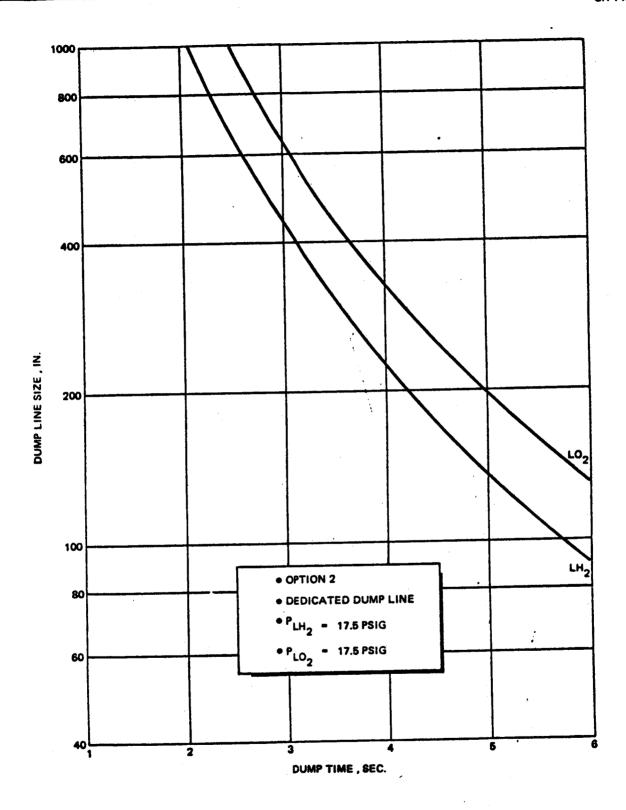


Figure 12.6-3.

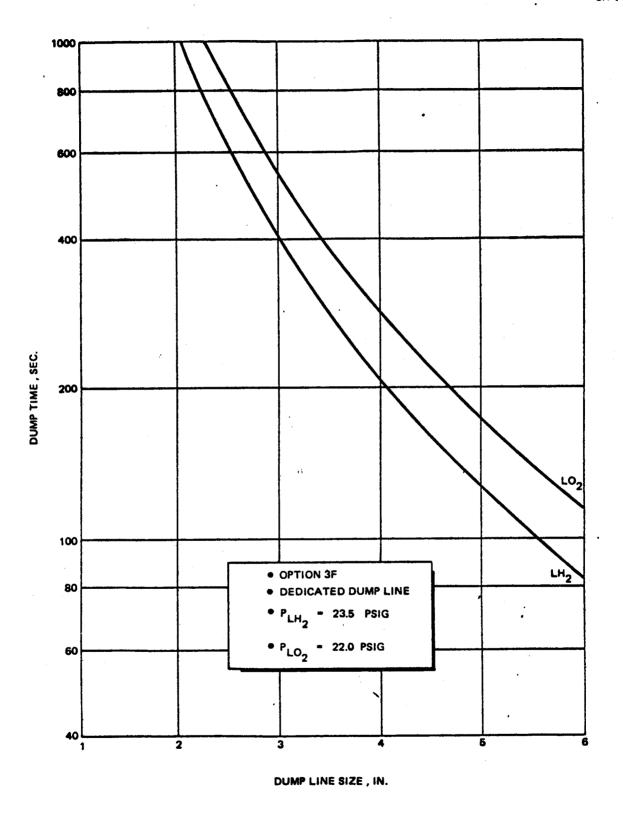


Figure 12.6-4.

the 3-inch abort line port location and the +Z g-force during thrust and heading reversal. The g-force trajectory profile is shown in Figure 12.6-5. The greatest tilt of the gas/liquid interface occurs at the start of abort with  $N_x = +1$  and  $N_z = +0.2$ . Tan  $\theta = 11.4^\circ$ . then the LO<sub>2</sub> abort line port must be more than 16 inches aft of the side centerline to

prevent unporting at 50% dump. Actually, the situation is a little worse due to 5% ullage gas volume at start of mission, placing the 50% LO<sub>2</sub> vertical line aft of the center-

line. Thus, assume 40% dump as a cutoff point at 40% x 635 = 254 sec.

635-254 = 381 seconds remain necessary to dump 100% of LO<sub>2</sub>. The 20% minimum dump of LO<sub>2</sub> necessary for CG control has thus been greatly exceeded before engine burnout. Either LH<sub>2</sub> or LO<sub>2</sub> can be dumped now.

Assume that LH<sub>2</sub> is dumped, according to the sequential dump alternative study option. To obtain 100% LH<sub>2</sub> dump in 135 seconds down to 110K ft will require a 5.0-inch line. The 381 seconds for subsequent dumping of LO<sub>2</sub> to depletion can occur from T+726 to T+1107, terminating at about 25K ft altitude.

#### Line-Optimized Option 3A - Sequential LO2 and LH2 Dumping

The following analysis is based on the round-trip mission loading data for Option 1. If  $LO_2$  is initially dumped in a late (T+251) Mode III abort to achieve an acceptable CG profile, about 20% or less of  $LO_2$  must be dumped. This requires 20% x 635 = 127 sec through a 3-inch  $LO_2$  abort dump line, leaving 635 - 127 = 508 seconds for glide period dumping of  $LO_2$ .  $LH_2$  dumping can occur for 280 - 127 = 153 seconds during engine thrusting. This is  $\frac{153}{1150}$  = 13.3% for 2-inch,  $\frac{153}{435}$  = 35.2% for 3-inch,  $\frac{153}{230}$  = 66.5% for 4-inch, or  $\frac{153}{135} > 100\%$  for 5-inch  $LH_2$  abort line.

ORBITER ASCENT ABORT MODE III LOAD FACTOR	o EASTERLY MISSION O LOSS OF ONE MAIN ENGINE O INPLANE MANEUVER O TABORT = 251 SEC ME BURNOUT	NX GLIDE XAILDE XA GLIDE XA	NOTE: ORBITER ROLL AT F REVERSES Ny ABORT  **ABORT**  *		1 2 3 4 5 6 T 8 9  1 2 3 4 5 6 T 8 9  PERATIVE VELOCITY ~1000 FT/SEC
		m N		LOAD PACTUR, M	
•					·

The glide period of 135 seconds would allow

 $\frac{135}{1150}$  = 11.7% for 2-inch,

 $\frac{135}{135}$  = 31.0% for 3-inch,

 $\frac{135}{230}$  = 58.7% for 4-inch, and

 $\frac{135}{135}$  = 100% for 5-inch line sizes

Therefore, the following composite of LH2 dump is obtained:

Line Size	Thrust Period	Glide Period	Total
2-inch	13.3%	11.7%	25.0%
3	35.2%	31.0%	66.2%
14	66.5%	58.7%	125.2%
5	>100%	100%	> 200%

The proper size for 100% dumping is less than 4-inch for the LH<sub>2</sub> abort dump line. Following the same side port location analysis as for LO<sub>2</sub>, if 41.3% of LH<sub>2</sub> is dumped during engine thrust through a 4-inch line, the remaining 58.7% can be dumped during glide to 110K ft.

The abort dumping time-line sequence then is as follows:

Abort Start: T+251

LO, Dump Start: T+251

LO<sub>2</sub> Dump Terminate: T+378 (20%)

LH, Dump Start: T+379

LH<sub>2</sub> Term: T+530.9 (41.3%)

LH<sub>2</sub> Dump Start: T+590.9

LH<sub>2</sub> Dump Term: T+726 (100%)

LO Dump Start: T+727

LO<sub>2</sub> Dump Term: T+1235 (100%)

Landing: T+1241

This abort profile is shown on Figure 12.6-6 for the worst-case condition -- late Mode III abort at T+251 with 50,800 lb of cryogens for a normal round-trip mission.

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CG ENVELOPE PAYLOAD LONGITUDINAL

LIMIT AFT

JSC-07700, VOL XIV

DESIGN SPEC

LIMIT

FWD

An early mode III abort at T+116 would permit 135 seconds more of initial LO<sub>2</sub> dumping, to a limit of 44.1% of LO<sub>2</sub> dumped. There is a family of options in this case within the design window defined by dashed lines on Figure 6.12.6-6, from 20% to 44.1% of initial LO<sub>2</sub> dump, followed by alternative dumping of LH<sub>2</sub>, followed by LO<sub>2</sub> until MECO - 30 sec; then depletion of LH<sub>2</sub> well above the 110K ft altitude, and finally LO<sub>2</sub> depletion at about T+1100 sec.

#### Conclusions

Two designs for sequential dumping of both LO<sub>2</sub> (normal) and LH<sub>2</sub> (optional) have been determined. Operational profiles for each have been defined to meet the constraints of CG compatibility, altitude, available time, and selected line size.

Option 1 - For LH<sub>2</sub> dumping only during glide return, preceded by up to 40% of LO<sub>2</sub> dump and followed by LO<sub>2</sub> depletion; a 5-inch LH<sub>2</sub> line would be provided in the LH<sub>2</sub> tank side location. A 3-inch LO<sub>2</sub> line would also be provided in the LO<sub>2</sub> tank side location.

Option 2 - For minimum LH<sub>2</sub> dump line sizing, LH<sub>2</sub> dumping (41.3%) would precede MECO - 30 seconds, and LH<sub>2</sub> depletion would follow MECO + 30 seconds down to 110K ft altitude. This requires a 4-inch LH<sub>2</sub> line, and the 3-inch LO<sub>2</sub> line permits a 20% LO<sub>2</sub> dump before the pre-MECO dump. It allows LO<sub>2</sub> depletion subsequent to LH<sub>2</sub> depletion, ending at 25K ft altitude or higher.

#### Option 3b - A Simultaneous LO2 and LH2 Dumping

While simultaneous dumping of both  $LO_2$  and  $LH_2$  have not been discussed in detail, it obviously is less constraining upon line size. Simultaneous dump operations can be inferred from the least time available on a late Mode III abort, which is 530.9 - 251 = 279.9 seconds pre-(MECO - 30 sec) and 726 - 590.9 = 135.1 seconds post-(MECO + 30 sec). Thus 415 seconds are available for  $LH_2$  dumping, which requires a 3.07-inch line diameter for depletion. The nominal 3-inch  $LO_2$  line will provide up to 44.1%  $LO_2$  dump prior to MECO - 30 sec and adequately provides CG compatibility before MECO.

A key constraint is imposed on simultaneous dumping by the presence of sensible atmosphere below a 400K ft altitude. The atmosphere produces a "wake" cffect

that may draw released cryogens back into the engine and boat-tail region and may thus produce a potential hazard as greater atmospheric pressure develops and ignition sources or static discharge may be present. Adequate separation of LO<sub>2</sub> and LH<sub>2</sub> abort line exits and injection of dumped cryogens well into the "slip-stream" should minimize this potential hazard down to 110K ft altitude.

#### 12.7 Other Sensitivities

#### Cryogenic Versus Storable Propellant ACPS Ground Operations

An analysis was performed to determine the effects on Option 3 ground operations which would result from utilizing a cryogenic attitude control system, rather than the baselined storable propellant systems. The impacts were investigated in the following four areas:

- 1. Maintenance and Refurbishment
- 2. Ground Support Equipment
- 3. Ground Operations Crew Size
- 4. Ground Turnsround Time

The analysis shows that a configuration change for Option 3 vehicles to a cryogenic ACPS would result in an operations cost increase of nearly \$1 million. In addition, this revision to the baselined configurations would increase the total program cost by nearly \$17 million.

#### Maintenance and Refurbishment

Option 3I utilizes a storable monopropellant ACPS, while Option 3F utilizes a storable bipropellant ACPS. The Option 3I configuration accomplishes 133 flights with four vehicles (33.3 flights per vehicle). The Option 3F configuration accomplishes 239 flights with eight vehicles (29.9 flights per vehicle). Scheduled maintenance and refurbishment costs for the baselined systems amounts to a total of \$76.000 (eight refurbishments at \$9,500 each, as shown in Table 6.12.7-1).

Utilizing the cryogenic ACPS in both the initial and final configurations results in the following scheduled ACPS maintenance and refurbishment operations.

#### Initial

Four refurbishments required = \$790,000

#### Final

Eight refurbishments required = \$1,580,000

The total program scheduled maintenance and refurbishment costs would therefore be increased a total of \$2,294,000 if the cryogenic ACPS was utilized during the Option 3 program.

Table 6.12.7-1

# ACPS REFURBISHMENT CHARACTERISTICS - STORABLE VS CRYOGENIC

	Sewert o	Operating Time		Missions before	Refr.	Scheduled Refurbishments per No. of Reuses	Scheduled Refurbishments per No. of Reuses	
ACPS Candidates	Life	Mission	Criteria Criteria	Scheduled Refurbishment	ଷ	50 100	100	
Mono-Propellant - 25 lb Thrust	Indefinite	340 sec	μK sec	12	п	#	-8	
Cryogenic - 25 lb Thrust	Indefinite	340 sec	9К вес	. 92	0	н	m	
				:				

### Note:

Refurbishment Criteria for Cryogenic ACPS was estimated at 50 percent of the operating life of a Category I The RL-10 and the Cryogenic ACPS have similar components and wear RL-10 Main Engine before refurbishment.

# ACPS REFURBISHMENT COSTS - STORABLE VS. CRYOGENIC

### Notes:

(1) Mono-Propellant ACPS refurbishment costs include only four axial (aft firing) thrusters.

Trogenic ACPS refurbishment costs include only ( , two primary turbomachinery/gas generator packa) <u>8</u>

#### Ground Support Equipment

The following list itemizes the changes to the ground support equipment which would result from incorporating a cryogenic ACPS in the Options 3I and 3F configurations:

Item No.	<u>Title</u>	Program Co	st Delta
		<u>3I</u>	<u>3F</u>
112	ACPS Loading Kit	- \$ 7,000	0
113	ACPS Servicer	- \$ 5,000	- \$4,800
117	C/O Accessory Kit	- \$ 6,000	0
139	Gas Sampling Kit	- \$ 300	0
152	Protection Equipment	- \$ 32,000	0
153	ACPS Test Set	- \$160,000	0
191	Workstands	- \$ 24,000	0
	Total Impact	- \$234,300	- \$4,800

#### Ground Operations Crew Size

The present baselined systems require transport of the Tug vehicles to the Storable Propellant Areas (at KSC and VAFB) for both post-flight safing and prelaunch servicing. The incorporation of a cryogenic ACPS in Options 3I and 3F will have three impacts on the ground crew size. First, the additional activities associated with loading at the launch pad and safing at the Shuttle Safing Area will increase the program required total ground crew (ETR plus WTR) by a total of 12 personnel. Second, during the 3I configuration ground turnaround cycles, the activities required at the Storable Propellant Facility would be eliminated. This would reduce the manpower required during these shifts of operations by a total of 24 people. Third, during the 3F configuration ground turnaround cycles, the activities originally required at the Storable Propellant Facility would be eliminated. This would reduce the manpower required during these shifts of operations by a total of 32 people.

The net effect on the ground crew sizing, analyzing the task sharing and shift manloading, would amount to two crewmen at KSC and one crewman at WTR during the first four years and one year, respectively. As Option 3F is introduced into the program at the fifth year, the net effect would amount to three

crewmen at KSC and two crewmen at VAFB, during the final seven years of the program. This equates to a cost savings of approximately \$1,100,000.

#### Ground Turnaround Time

The average ground turnaround times for the Option 3 vehicles would be reduced if the cryogenic ACPS were to be utilized. The average turnaround time for 3I would be reduced from 39 to 35 shifts. The average turnaround time for 3F would be reduced from 43 to 37 shifts. Reviewing the traffic model, launch rates, and nominal fleet sizes for Option 3, these reductions do not revise the number of required flight articles.

#### Summary

The ground operations impact which would result from incorporating cryogenic ACPS into the two configurations is summarized below.

	<u>3I</u>	<u>3F</u>
Maintenance Impact	+ \$714,000	+ \$1,580,000
GSE Impact	- \$234,300	- \$ 4,800
Crew Impact	- \$225,000	- \$ 875,000
Total Impact	+ \$254,700	+ \$ 700,200

In order to review the total impact to program costs, Figure 6.12.7-1 summarizes the delta cumulatize costs to DDT&E, Production, and Operations for Option 3 with cryogenic ACPS. As may be seen, this change results in a total cost increase of nearly \$17 million to the Option 3 program.

#### 13.0 ON ORBIT SERVICING IMPACT

The on orbit servicing impact study was specified for performance on Option 2. The reader is referred to Vol 6, Option 2, section 13.0 for the detailed analysis.